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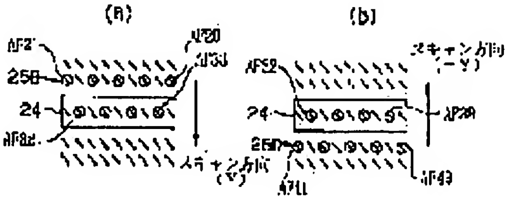
(54) PLANE POSITION SETTING DEVICE

(57)Abstract:

PURPOSE: To align an exposure face of a photosensitive board with an image face of a projection optical system with high precision in a projection aligner using a slit-scanning exposure system.

CONSTITUTION: When a wafer is scanned being exposed in a Y-direction against a slitted exposing field 24, the leveling and focusing for the wafer are controlled based on the information on the focus positions which are obtained from the sample points AF21 to AF29 of a second row 25B on this side against the scanning direction and from the sample points AF 32 to AF38 in the field 24. On the other hand, when the wafer is scanned being exposed in a -Y-direction, the leveling and focusing are controlled based on the information on the focus positions which are obtained from the sample points AF41 to AF49 of a fourth row 25D on this side against the scanning direction and from the sample points AF32 to AF38 in the field 24.



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CLAIMS

[Claim(s)
[Claim 1 An illumination-light study system which illuminates an illuminated field of specified shape by exposing light.
The mask side stage which scans a mask in which a pattern for exposure was formed to said illuminated field, a projection optical system which projects a pattern of said mask in said illuminated field on a sensitized substrate, and the substrate side stage which scans said sensitized substrate synchronizing with said mask.
A multipoint measurement means which is the surface position setting device provided with the above, and measures height of a direction parallel to an optic axis of said projection optical system of said sensitized substrate in two or more measure points including two or more points of a direction which crosses in the direction by which said sensitized substrate is scanned, respectively, A calculating means which asks for difference of an angle of inclination between an exposure surface of said sensitized substrate, and the image surface of said projection optical system from a measuring result of this multipoint measurement means, Based on difference of said angle of inclination which was provided in said substrate side stage and called for by said calculating means, Speed of response in case it has an inclination setting-out stage which sets up an angle of inclination of a direction which intersects perpendicularly in an angle of inclination of the direction of said scan of said sensitized substrate, and the direction of said scan and this inclination setting-out stage sets up an angle of inclination of the direction of said scan of said sensitized substrate, Speed of response when setting up an angle of inclination of a direction which intersects perpendicularly towards said scan was made to differ.

[Claim 2 The surface position setting device according to claim 1 when said multipoint measurement means is scanned [said sensitized substrate via said substrate side stage, wherein it samples height of said sensitized substrate in said two or more measure points by a datum reference of said substrate side stage.

[Claim 3 In two or more measure points when said multipoint measurement means becomes from two or more points in a field of this side at the time of said sensitized substrate being scanned to inside of two or more points in a conjugate exposure region, and said conjugate exposure region about an illuminated field and said projection optical system of said specified shape, The surface position setting device according to claim 1 or 2 measuring height of said sensitized substrate, respectively.

[Claim 4 The surface position setting device according to claim 1, wherein said multipoint measurement means changes a position of two or more of said measure points to one shot region of said sensitized substrate one by one in a process in which a pattern of said mask is exposed one by one.

[Claim 5 An illumination-light study system which illuminates an illuminated field of specified shape by exposing light, comprising, The mask side stage which scans a mask in which a pattern for exposure was formed to said illuminated field, A projection optical system which projects a pattern of said mask in said illuminated field on a sensitized substrate, It is provided in an exposure device which has the substrate side stage which scans said sensitized substrate synchronizing with said mask, A predetermined measure point in a measuring region which is a surface position setting device for doubling height of an exposure surface of said sensitized substrate with the image surface of said projection optical system, and consists of a field of this side at the time of said sensitized substrate being scanned to a conjugate exposure region and this exposure region about an illuminated field and said projection optical system of said specified shape.

A height measurement means to measure height of a direction parallel to an optic axis of said projection optical system of said sensitized substrate.

A calculating means which asks for difference of average height of an exposure surface of said sensitized substrate, and height of the image surface of said projection optical system based on the maximum and the minimum of two or more height measurement results obtained by said height measurement means when said sensitized substrate is scanned.

A height setting-out stage which sets up height of said sensitized substrate based on difference of said height which was provided in said substrate side stage and found by said calculating means.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention
[0001]
[Industry-like field of the invention This invention is applied, for example to the autofocusing mechanism or auto leveling mechanism of a projection aligner of a slit scan exposure system, and relates to a suitable surface position setting device.
[0002]
[Description of the Prior Art When manufacturing a semiconductor device, a liquid crystal display element, or a thin film magnetic head by a photolithography process, the projection aligner which transfers a photo mask or the pattern of reticle (it is hereafter named reticle generically) on the substrates (a wafer, a glass plate, etc.) with which it was applied to sensitization material is used. As a conventional projection aligner, each shot region of the wafer was moved into the exposure field of a projection optical system one by one, and many reduction projection type exposure devices (stepper) of the step-and-repeat method of exposing the pattern image of reticle one by one to each shot region were used.
[0003]Drawing 20 shows the conventional stepper's important section, in this drawing 20, it is a basis of exposing light EL from the illumination-light study system by which the graphic display abbreviation was carried out, and projection exposure of the image of the pattern on the reticle 51 is carried out to each shot region on the wafer 53 in which photoresist was applied via the projection optical system 52. The wafer 53 is held on Z leveling stage 54, and Z leveling stage 54 is laid on wafer side XY stage 55. In a flat surface (XY plane) vertical to optic-axis AX1 of the projection optical system 52, wafer side XY stage 55 positions the wafer 53, and Z leveling stage 54, It is set as the state where the focusing position (position of a direction parallel to optic-axis AX1) of the exposure surface of the wafer 53 and the angle of inclination of the exposure surface were specified.
[0004]The moving mirror 56 is being fixed on Z leveling stage 54. The laser beam from the

external laser interferometer 57 is reflected with the moving mirror 56, the X coordinate and Y coordinate of wafer side XY stage 55 are always detected by the laser interferometer 57, and these X coordinates and a Y coordinate are supplied to the main control system 58. The main control system 58 exposes the pattern image of the reticle 51 one by one to each shot region on the wafer 53 by a step-and-repeat method by controlling operation of wafer side XY stage 55 and Z leveling stage 54 via the drive 59.

[0005]Under the present circumstances, although the pattern formation face (reticle side) on the reticle 51 and the exposure surface of the wafer 53 need to have conjugate about the projection optical system 52, since their projecting magnification is high and they are large, a reticle side is seldom changed. [of the depth of focus] Then, generally it is detected conventionally whether the exposure surface of the wafer 53 has agreed within the limits of the depth of focus in the image surface of the projection optical system 52 according to the focal position detection system of an oblique-incidence type multipoint (is it focusing or not?), Control of the focusing position of the exposure surface of the wafer 53 and the angle of inclination was performed.

[0006]In the focal position detection system of the conventional multipoint, the illumination light which does not expose the photoresist on the wafer 53 unlike exposing light EL is drawn via the optical fiber bundle 60 from the illumination light source by which the graphic display abbreviation was carried out. The illumination light ejected from the optical fiber bundle 60 illuminates the pattern formation board 62 through the condenser 61. The illumination light which penetrated the pattern formation board 62 is projected on the exposure surface of the wafer 53 through the lens 63, the mirror 64, and the exposure object lens 65, and projection imaging of the image of the pattern on the pattern formation board 62 is aslant carried out to optic-axis AX1 in the exposure surface of the wafer 53. The illumination light reflected with the wafer 53 is re-projected on the electric eye 69 in an acceptance surface through the condensing object lens 66, the hand-of-cut diaphragm 67, and the image formation lens 68, and re-image formation of the image of the pattern on the pattern formation board 62 is carried out to the acceptance surface of the electric eye 69. In this case, the main control system 58 gives vibration like the after-mentioned to the hand-of-cut diaphragm 67 via the excitation apparatus 70, The detecting signal from many photo detectors of the electric eye 69 is supplied to the signal processor 71, and the signal processor 71 supplies the focusing signal of a large number which acquired it by carrying out synchronous detection of each detecting signal with the driving signal of the excitation apparatus 70 to the main control system 58.

[0007]As drawing 21 (b) shows the opening pattern formed on the pattern formation board 62 and shows it to this drawing 21 (b), on the pattern formation board 62, the nine slit shape opening patterns 72-1 to 72-9 are formed at cross shape. Since it is irradiated with those opening patterns 72-1 to 72-9 from the direction which crosses at 45 degrees to the X-axis and a Y-axis to the exposure surface of the wafer 53, Each projection images AF1-AF9 of these opening patterns 72-1 to 72-9 in the exposure field of the projection optical system 52 on the exposure surface of the wafer 53 become arrangement as shown in drawing 21 (a). In drawing 21 (a), it is inscribed in the circular lighting field of the projection optical system 52, the maximum exposure field 74 is formed, and the projection image of the slit shape opening pattern is projected on the center section in the maximum exposure field 74, and the measure points AF1-AF9 on two diagonal lines, respectively.

[0008]As drawing 21 (c) shows the situation of the acceptance surface of the electric eye 69 and shows it to this drawing 21 (c), the nine photo detectors 75-1 to 75-9 are arranged in the acceptance surface of the electric eye 69 at a cross-joint type, and the gobo (graphic display abbreviation) which has a slit shape opening is arranged on each photo detector 75-1 to 75-9. And re-image formation of the image on each measure point AF1 of drawing 21 (a) - AF9 is carried out on each photo detector 75-1 to 75-9 of the electric eye 69, respectively. In this case, the illumination light reflected in the exposure surface (wafer surface) of the wafer 53 of drawing 20, Since it exists in the pupil posion of the condensing object lens 66 and is reflected by the hand-of-cut diaphragm 67 which vibrates around an axis almost vertical to the space of drawing 20 (rotational vibration), As shown in drawing 21 (c), on the electric eye 69, the position of the projection image by which re-image formation is carried out on each photo detector 75-1 to 75-9 vibrates in the direction of RD which is the cross direction of a slit shape opening.

[0009]Since the image of the slit shape opening on each measure point AF1 of drawing 21 (a) - AF9 is aslant projected to the optic axis of the projection optical system 52, if the focusing position of the exposure surface of the wafer 53 changes, the re-image formation position on the electric eye 69 of these projection images will change in the direction of RD. Therefore, nine focusing signals respectively corresponding to the focusing position of the measure points AF1-AF9 are acquired within the signal processor 71 by carrying out synchronous detection of the detecting signal of each photo detector 75-1 to 75-9 by the vibration applying signal of the hand-of-cut diaphragm 67, respectively. And from the focusing position of nine pieces, the angle of inclination of the average field of the exposure field 74 and the focusing position of the average field are called for, and the main control system 58 is supplied and the main control system 58, The focusing position and angle of inclination (leveling angle) of the shot region concerned of the wafer 53 are set as a predetermined value via the drive 59 and Z leveling stage 54. Thus, in the stepper, in each shot region of the wafer 53, a focusing position and an angle of inclination are in the state where it doubled with the image surface of the projection optical system 52, and the pattern image of the reticle 51 was exposed, respectively.

[0010]

[Problem(s) to be Solved by the Invention In recent years, since the pattern is carrying out minuteness making in the semiconductor device etc., heightening the resolution of a projection optical system is called for. Although techniques, such as increase of the short wavelength formation of the wavelength of exposing light or the numerical aperture of a projection optical system, are one of the techniques for heightening resolution, If it is going to secure the exposure field of the same grade as a conventional example even when using which technique, it will become difficult to maintain image formation performances (distortion, a curvature of field, etc.) for predetermined accuracy all over an exposure field. Then, the so-called projection aligner of a slit scan exposure system is improved now.

[0011]In the projection aligner of this slit scan exposure system, the pattern of that reticle is exposed on a wafer, synchronizing relatively and scanning reticle and a wafer to rectangular shape or the illuminated field (henceforth "a slit shape illuminated field") of circular **. Therefore, the image was equalized in said slit shape illuminated field and the conjugate field, and there was an advantage that distortion accuracy improved.

[0012]Although the mainstream of the size of the conventional reticle was 6 inch sizes and the mainstream of the projecting magnification of a projection optical system was 1 5 time, the size of the reticle in a basis 1/5 time the magnification of this has stopped 6 inch sizes being of use by large area-ization of circuit patterns, such as a semiconductor device. Therefore, it is necessary to design the projection aligner which changed the projecting magnification of the projection optical system 1 4 time. And the slit scan exposure system which can make small the diameter of an exposure field of a projection optical system to large-area-izing of such a transferred pattern is advantageous also in a cost aspect.

[0013]Even if the focal multipoint type position detection system used by the conventional stepper is applied as it is in the projection aligner of this slit scan exposure system and it measures the focusing position and angle of inclination of an exposure surface on a wafer, Since the wafer was scanned in the predetermined direction, there was inconvenience that it was difficult to double a actual exposure surface with the image surface of a projection optical system. That is, probability of the technique for doubling the focusing position and angle of inclination of a wafer with the image surface of a projection optical system in the projection aligner of a slit scan exposure system conventionally was not carried out.

[0014]In view of this point, an object of this invention is to provide the surface position setting device which can be used in order to double the exposure surface of a sensitized substrate with high precision to the image surface of a projection optical system in the projection aligner of a slit scan exposure system.

[0015]

[Means for Solving the Problem An illumination-light study system in which the 1st surface position setting device of this invention illuminates an illuminated field of specified shape by exposing light, The mask side stage (10) which scans a mask (12) in which a pattern for exposure was formed to the illuminated field, A projection optical system (8) which projects a pattern of a mask (12) in the illuminated field on a sensitized substrate (5), It is provided in an exposure device which has the substrate side stage (2) which scans a sensitized substrate (5) synchronizing with a mask (12), It is a surface position setting device for doubling an exposure surface of a sensitized substrate (5) in parallel with the image surface of a projection optical system (8), A multipoint measurement means (62A, 69A) which measures height of a direction parallel to an optic axis of a projection optical system (8) of a sensitized substrate (5) in two or more measure points (AF11-AF59) including two or more points of a direction which crosses in the direction by which a sensitized substrate (5) is scanned, respectively, It has a calculating means (71A) which asks for difference of an angle of inclination between an exposure surface of a sensitized substrate (5), and the image surface of a projection optical system (8) from a measuring result of this multipoint measurement means.

[0016]Based on difference of the angle of inclination which this invention was provided in the substrate side stage (2), and was called for by a calculating means (71A), As it has an inclination setting-out stage (4) which sets up an angle of inclination of a direction (the direction of X) which intersects perpendicularly in an angle of inclination of the direction (the direction of Y) of the scan of a sensitized substrate (5), and the direction of the scan, for example, is shown in drawing 5, Speed of response in case an inclination setting-out stage (4) sets up angle-of-inclination θ_Y of the direction (the direction of Y) of the scan of a sensitized substrate (5) is made to differ from speed of response when setting up angle-of-inclination θ_X of a direction (the direction of X) which intersects perpendicularly towards the scan.

[0017]In this case, that multipoint measurement means may sample height of a sensitized substrate (5) in a measure point of these plurality by a datum reference of the substrate side stage (2), when a sensitized substrate (5) is scanned via the substrate side stage (2). In two or more measure points when the multipoint measurement means becomes from two or more points in a field of this side at the time of a sensitized substrate (5) being scanned to inside of two or more points in a conjugate exposure region (24), and a conjugate exposure region of those about an illuminated field and a projection optical system (8) of the specified shape, Height of a sensitized substrate (5) may be measured, respectively.

[0018]As for the multipoint measurement means, it is desirable to change a position of a measure point of these plurality to one shot region of a sensitized substrate (5) one by one in a process in which a pattern of a mask (12) is exposed one by one. The 2nd surface position setting device by this invention, The mask side stage (10) which scans a mask (12) in which a pattern for exposure was formed to an illumination-light study system which illuminates an illuminated field of specified shape, and its illuminated field by exposing light, A projection optical system (8) which projects a pattern of a mask (12) in the illuminated field on a sensitized substrate (5), It is provided in an exposure device which has the substrate side

stage (2) which scans a sensitized substrate (5) synchronizing with a mask (12), It is a surface position setting device for doubling height of an exposure surface of a sensitized substrate (5) with the image surface of a projection optical system (8), In a predetermined measure point in a measuring region which consists of a field of this side at the time of a sensitized substrate (5) being scanned to a conjugate exposure region (24) and this exposure region about an illuminated field and a projection optical system (8) of that specified shape, A height measurement means (62A, 69A) to measure height of a direction parallel to an optic axis of a projection optical system (8) of a sensitized substrate (5), It is provided in a calculating means (71A) which asks for difference of average height of an exposure surface of a sensitized substrate (5), and height of the image surface of a projection optical system (8) based on the maximum and the minimum of two or more height measurement results obtained by the height measurement means when a sensitized substrate (5) is scanned, and the substrate side stage (2), Based on difference of the height found by a calculating means (71A), it has a height setting-out stage (4) which sets up height of a sensitized substrate (5).
[0019]
[Function]In the 1st surface position setting device of this this invention, When scanning a mask (12) and a sensitized substrate (5) synchronously and exposing the pattern image of a mask (12) on a sensitized substrate (5), the height of a sensitized substrate (5) is measured using the multipoint measurement means in two or more measure points which contain the measure point before the direction of the scan, for example. And it asks for the angle of inclination of a sensitized substrate (5) by acquiring multiple-times height information in accordance with the direction of a scan, respectively in the measure point of these plurality. Then, when exposing the pattern image of a mask (12) to the field to which the angle of inclination was called for such, the angle of inclination of the field is set up based on the angle of inclination for which it asked beforehand. Thereby, the exposure surface of a sensitized substrate (5) is set up in parallel with the image surface of a projection optical system (8) also with a slit scan exposure system.
[0020]In this invention, when performing such leveling, the speed of response of leveling of a scanning direction differs from the speed of response of non-scanning direction leveling. In order to explain per by this operation effect, focusing at the time of slit scan exposure and the error factor of leveling are explained. The following errors can be considered with the exposure device of a slit scan exposure system.
** A focal offset error and a vibration error focus offset error are differences of the focusing position of the average field of an exposure surface, and the image surface of a projection optical system, and a vibration error is an error resulting from vibration of the focusing direction of the substrate side stage at the time of carrying out scanning exposure, etc. It divides, when carrying out one-shot exposure like a stepper as what performs only autofocus control, and

when exposing with a slit scan exposure system, and this is explained more to details.

[0021]When carrying out one-shot exposure of drawing 14 (a), it shows the case where drawing 14 (b) is exposed with a slit scan exposure system. In drawing 14 (a), although the average field 34 of the exposure surface 5a of a sensitized substrate has agreed in the image surface of a projection optical system, -deltaZ1 and 0 differ only from deltaZ2 to the average field 34 where the focusing position of the positions Ya, Yb, and Yc is constant respectively. Therefore, the focal offset errors in the positions Ya and Yb are -deltaZ1 and deltaZ2, respectively.

[0022]On the other hand, in the case of drawing 14 (b), a series of partial average sides 35A, 35B, and 35C on the exposure surface 5a and .... double one by one to a scanning direction in the image surface of a projection optical system. Therefore, the focal offset error in each positions Ya, Yb, and Yc is set to 0 by the equalization effect, respectively. However, although the image on position Yb is formed, since a focusing position moves between height deltaZB (s) from the average side 35B to the average side 35D, the image on position Yb will turn into an image to which only delta ZB had dispersion in the focusing direction. Similarly, the image on the position Ya and Yc turns into an image to which only delta ZA and delta ZB had dispersion in the focusing direction, respectively.

[0023]Namely, in a slit scan exposure system, although a focal offset error is set to about 0 to unevenness of the sensitized substrate side below a certain constant frequency, Rolling of the substrate side stage, pitching, vibration of a focusing direction (Z shaft orientations), The wavelength variation of the short period of the error component by an autofocusing mechanism and an auto leveling mechanism following a low frequency wave air fluctuation error and exposing light (KrF excimer laser light etc.), etc. produce a new error (vibration error).

[0024]** Although it is a typical example of the vibration errors which made reference by focal following error, air fluctuation error, and stage vibration error and these are dependent on the response frequency of an autofocusing mechanism and an auto leveling mechanism, it can classify into the following errors.

(1) (2), such as a high frequency stage vibration error, a wavelength variation error of the short period of exposing light (KrF excimer laser light etc.), etc. uncontrollable by a control system In an air fluctuation error, (3), such as a low frequency wave air fluctuation error which the substrate side stage follows Error of measurement etc. which do not turn into a focus error since the substrate side stage does not follow, although contained in the measurement result of a focal position detection system or an angle-of-inclination detection system.

[0025]** The error of ****** by unevenness of the exposure surface of a sensitized substrate is a field unit two-dimensional in the exposure field by a projection optical system.

It is an error resulting from being a measure point of a limited individual and performing measurement of the focusing position in the exposure surface of a sensitized substrate at the time of slit scan exposure, and can classify into the following two errors.

(1) . For example, originate in the arithmetic method for the position of the measure point in the case of measuring a focusing position by the multipoint on the exposure surface 5a of a sensitized substrate, and searching for the alignment object faces (focal field) 36A and 36B, as shown in drawing 15 (a) and (b). The error of the gap with the focal side 36A and an ideal focus side, and (2) Error by the speed of response of a difference with the slew rate of scanning speed, an autofocusing mechanism, and an auto leveling mechanism, and a focal position detection system, etc.

[0026]In this case, the speed of response in the case of doubling a focusing position with the image surface of a projection optical system (focal response) is determined by a time lag error as shown in drawing 15 (c), and the servo gain as shown in drawing 15 (d). Namely, in drawing 15 (c) the curve 37A, The driving signal for the focusing directions for doubling a series of subregions of the exposure surface 5a of a sensitized substrate with the image surface of a projection optical system one by one (target focus position signal) is shown, and the curve 38A, The signal (flattery focus position signal) acquired by converting the movement magnitude to the focusing direction of a series of subregions of the exposure surface 5a into a driving signal is shown. Only fixed time is behind in the curve 38A to the curve 37A. Similarly, in drawing 15 (d), the curve 37B is a target focus position signal of a series of subregions of the exposure surface 5a of a sensitized substrate, and the curve 38B is a flattery focus position signal of a series of subregions of the exposure surface 5a.

The amplitude (servo gain) of the curve 38B is small only the constant rate to the curve 37B.

[0027]In the 1st surface position setting device of this invention, in order to remove these errors, the response of the scanning direction of a leveling mechanism and the response of the non-scanning direction are changed. It is premised on the focal position detection system of an oblique incidence type multipoint as a multipoint measurement means for auto leveling mechanisms in this invention. It aims at making the maximum of the gap with each point of the exposure surface in the predetermined field, and the image surface of a projection optical system into the minimum regardless of the average field of the exposure surface of the sensitized substrate in the predetermined field in the exposure field of a projection optical system. Thus, in the predetermined field in the exposure field of a projection optical system, an exposure field in case the maximum of the gap with almost all the points of the exposure surface of a sensitized substrate and the image surface of a projection optical system is the minimum is called "the good field (Good Field)."

[0028]First, as shown in drawing 16, it is assumed that many measure points (un-illustrating) of a focusing position are in the slit shape conjugate exposure field 24 about slit shape illuminated field and projection optical system. In drawing 16, as what scans one shot region SA_{ij} on a sensitized substrate by speed V beta in the direction of Y to the slit shape exposure field 24, Width of the scanning direction of WX and the exposure field 24 is set the width of the scanning direction of shot region SA_{ij}] to D for the width of WY and a non-scanning direction. By equalizing the focusing position in many measure points in the central region 24a in the exposure field 24, It asks for the focusing position of the average field in the central point of the exposure field 24, Based on the least squares approximation, angle-of-inclination $theta_Y$ of the scanning direction of an average field is calculated from the measuring region 24b of the both ends of the scanning direction of the exposure field 24, and the focusing position in the measure point in 24c, Based on the least squares approximation, angle-of-inclination $theta_X$ of the non-scanning direction of an average field shall be calculated from the measuring region 24b of the both ends of the non-scanning direction of the exposure field 24, and the focusing position in the measure point in 24c. Response frequency of leveling of fm Hz and a non-scanning direction is set to fn [Hz for the response frequency of leveling of a scanning direction, and the value of fm and fn is set up independently.

[0029]And the cycle of a periodic bend of the scanning direction of shot region SA_{ij} on a sensitized substrate, Bend as a value of a ratio with the width WY (a non-scanning direction is also set as the same bend cycle) of a scanning direction, and it expresses with the parameter F, The focus error in each measure point in the exposure field 24 in case there is the periodic bend is expressed with the absolute value of the average value of the focus error at the time of scanning, and one third of the sums of the amplitude of the focus error at the time of scanning. The amplitude of a periodic bend of the bend parameter F is standardized to 1, and error parameter S which shows the maximum of the focus errors in these each measure point in case a bend parameter is F is expressed as a ratio to the bend parameter F. That is, the following formula is materialized.

The cycle/WY of F bend (1)

The maximum F of S focus error (2)

[0030]Drawing 17 (a) expresses error parameter S to the bend parameter F when the response frequency fm of leveling of a scanning direction and the response frequency fn of leveling of a non-scanning direction are equal and large, The curve A1 Error parameter in a non-scanning direction] S, the absolute value of the average value of a focus error usual in error parameter S of a non-scanning direction] in the curve B1, The curve A2 shows the average value of error parameter in a scanning direction S, and a focus error usual in error parameter S of a scanning direction] in curvilinear B-2. The curve A1 and the curve A2 express the respectively more realistic focus error. When when the value of the meter F is small] the cycle of unevenness of an exposure surface is small, the flattery nature of leveling control of a scanning direction understands that leveling control of a scanning direction comes to follow a bend bad (curve A2) as a concavo-convex cycle becomes large. Since a focusing position does not change one by one like a scanning direction to a non-scanning direction, even if the cycle of a bend becomes large, it is worse than the flattery nature of a scanning direction (curve A1). As mentioned above, it is desirable for a focus error to become so that the parameter S may become 0.5 or less, but a scanning direction and the non-scanning direction of a focus error are large as a whole.

[0031]On the other hand, the response frequency fm of drawing 17 (b) of leveling of a scanning direction is larger than the response frequency fn of leveling of a non-scanning direction, And error parameter S to the bend parameter F when both the response frequency fm and fn is small is expressed, As for curvilinear A3, error parameter in a non-scanning direction] S, the absolute value of the average value of the focus error of a non-scanning direction usual in the curve B3, and curvilinear A4 show error parameter in a scanning direction] S, and curvilinear B4 shows the absolute value of the average value of the usual focus error in a scanning direction. Comparison with drawing 17 (a) and drawing 17 (b) shows that the direction of a focus error when response frequency is almost smaller than the case of a full response (drawing 17 (a)) (drawing 17 (b)) is [in which error parameter S is close to 0.5] small. This is for the fine point on a sensitized substrate that accuracy will get worse in the slit shape exposure field 24 if an auto leveling mechanism follows unevenly to occur. However, since it becomes impossible to follow to the uneven part of a low frequency wave when response frequency is made small too much, it is necessary to set response frequency as a suitable value.

[0032]In the example of drawing 17 (b), the response frequency fm of leveling of a scanning direction is set up more highly than the response frequency fn of leveling of a non-scanning direction. The response frequency for following unevenness of an exposure surface good, since a cycle becomes short substantially according to slit width in a scanning direction even if this is unevenness of the same bend parameter F is because it is necessary to make it higher than a non-scanning direction in a scanning direction.

[0033]In two or more measure points when the multipoint measurement means for auto leveling mechanisms becomes from two or more points in the field of this side at the time of a sensitized substrate (5) being scanned to the inside of two or more points in a conjugate exposure region (24), and the conjugate exposure region of those about the illuminated field and projection optical system (8) of the specified shape, When measuring the height of a sensitized substrate (5), respectively, in a front measure point, prediction of a focusing position is performed selectively. This is called division destination reading. Therefore, compared with the technique (full prediction) of predicting in all measure points, the length at the time of reading a focusing position by a multipoint measurement means by exposure (entrance length) is shortened.

[0034]In the process in which the multipoint measurement means exposes the pattern of a mask (12) one by one to one shot region of a sensitized substrate (5), In changing the position of the measure point of these plurality one by one, for example at the end of the shot region, division destination reading is performed, and henceforth the center section of the shot region], full prediction is performed and it checks open control in an exposure position primary detecting element. Thereby, where leveling accuracy is maintained with high precision, the entrance length in the end of a shot region can be shortened, and the throughput of exposure can be raised.

[0035]Next, the autofocus control in the 2nd surface position setting device of this invention is considered. If the concept of the above-mentioned good field (Good Field) is taken in, as shown in drawing 16, Equalizing processing of the focusing position of each measure point in the center section 24a of the exposure field 24 is performed, and if the field shown by the average value of the focusing position is doubled with the image surface of a projection optical system, accuracy may get worse. That is, drawing 18 (a) shows the field 34A corresponding to the average value of the focusing position of each measure point of the exposure surface 5a with the crevice of depth H of a sensitized substrate, and the difference deltaZ3 of the focusing direction of the field 34A and crevice is larger than H 2.

[0036]On the other hand, in this invention, the maximum and the minimum of a focusing position of each measure point in a measuring region predetermined [on the exposure surface 5a] are calculated, and the field corresponding to the middle focusing position of these maximums and the minimum is doubled with the image surface of a projection optical system. . Drawing 18 (b) can be set to the exposure surface 5a with the crevice of depth H of a sensitized substrate. The field 34B corresponding to the middle focusing position of maximum Z_{max} of the focusing positions of each measure point and minimum Z_{min} can be shown, and focusing position Z_{34B} of the field 34B can be expressed as follows.

$Z_{34B}=(Z_{max}+Z_{min})/2$ (3)

[0037]Then, the field 34B doubles with the image surface of a projection optical system. The difference deltaZ4 of the focusing direction of the field 34B and the surface of the exposure surface 5a and the difference deltaZ5 of the focusing direction of the field 34B and its crevice have become two in about H , respectively. Namely, since the maximum of the error of a focusing position [in / in the direction of the field 34B of drawing 18 (b) / each point on the exposure surface 5a becomes small compared with the field 34A of drawing 18 (a), On the concept of the good field (Good Field), the exposure surface of a sensitized substrate can be doubled more with the image surface of a projection optical system by this invention at high degree of accuracy.

[0038]At the same time it makes the response frequency fm of leveling of a scanning direction, and response frequency fn of leveling of a non-scanning direction equally and large and performs auto leveling control like drawing 17 (a), The characteristic of error parameter S to the bend parameter F at the time of performing autofocus control based on the equalizing processing of drawing 18 (a) or autofocus control based on the average value of the maximum of drawing 18 (b) and the minimum is shown in drawing 19 (a) and (b), respectively. That is, in drawing 19 (a) based on equalizing processing, as for curvilinear A5 and B5, error parameter S, the curve A6, and B6 of a non-scanning direction express error parameter S of a scanning direction, respectively. In drawing 19 (b) based on the average value of the maximum and the minimum, the curves A7 and B7 express error parameter of a non-scanning direction] S, and the curves A8 and B8 express error parameter S of a scanning direction, respectively.

[0039]When autofocus control is performed like it is and based on the average value of the maximum and the minimum from drawing 19 (b), In all the bend parameters F, i.e., all frequency bands, the value of error parameter S is close to 0.5, and the maximum of the focus error is small compared with the case where autofocus control is performed based on equalizing processing.

[0040]When only autofocus control is performed based on the average value of the maximum of a focusing position and the minimum which returned to drawing 15 (a) and (b), and were obtained in the measure point in a predetermined measuring region, As shown in drawing 15 (a), the field 36A of deltaZa doubles with the image surface of a projection optical system in the difference of a focusing position with the maximum to the exposure surface 5a which has a bend of amplitude 2 and deltaZa. Based on the average value of the focusing position only obtained in these measure points on the other hand to the exposure surface 5a which has a bend of amplitude 2 and deltaZa, perform autofocus control, and. When auto leveling control is performed based on the least squares approximation of the obtained focusing position, as shown in drawing 15 (b), the field 36B of deltaZb (>deltaZa) may double with the image surface of a projection optical system in the difference of the focusing position from the maximum within the limits of amplitude deltaZc (>2 and deltaZa). Therefore, in the direction which performs autofocus control based on the average value of the maximum of a focusing position and the minimum which were obtained, a focus error becomes small, when using an auto leveling mechanism, or even when not using it.

[0041]Although controlled by this invention to double with the image surface the field which becomes settled in (minimum [of the maximum Z_{max}+ focusing position of a focusing position] Z_{min}) / 2, Depending on a device process, which depth of focus of the heights of the exposure surface 5a of a sensitized substrate or a crevice may be required. Therefore, it is desirable to perform control which doubles with the image surface the field of focusing position Z_{MN} which becomes settled in proportional distribution like a following formula using the predetermined coefficients M and N.

$Z_{MN}=(M-Z_{max}+N-Z_{min})/(M+N)$ (4)

[0042]

[Example Hereafter, with reference to drawings, it explains per example of this invention. This example applies this invention to the autofocusing mechanism and auto leveling mechanism of a projection aligner of a slit scan exposure system. The illuminated field of the rectangle by exposing light EL from the illumination-light study system by which drawing 1 showed the projection aligner of this example, and the graphic display abbreviation was carried out in this drawing 1. The pattern on the reticle 12 is illuminated by (it is hereafter called "a slit shape illuminated field"), and projection exposure of the image of the pattern is carried out on the wafer 5 via the projection optical system 8. Under the present circumstances, it synchronizes with the reticle 12 being scanned with the constant speed V in the direction of this side (or other side) to the space of drawing 1 to the slit shape illuminated field of exposing light EL, The wafer 5 is scanned by the other side (or the direction of this side) to the space of drawing 1 by constant speed V beta (1 beta is the reducing magnification of the projection optical system 8).

[0043]The reticle Y drive stage 10 which can be freely driven on the reticle buck 9 in Y shaft orientations (direction vertical to the space of drawing 1) is laid for explaining the drive system of the reticle 12 and the wafer 5, The reticle minute drive stage 11 is laid on this reticle Y drive stage 10, and the reticle 12 is held by the vacuum chuck etc. on the reticle minute drive stage 11. As for the reticle minute drive stage 11, only a fine amount performs position control of the reticle 12 to the direction parallel to space of X, the direction of Y, and hand of cut (the direction of theta) of drawing 1 with high precision in a field vertical to the optic axis of the projection optical system 8, respectively. The position of the direction of X of the reticle minute drive stage 11, the direction of Y, and the direction of theta is always monitored by the interferometer 14 which the moving mirror 21 has been arranged on the reticle minute drive stage 11, and has been arranged on the reticle buck 9. The position information S1 acquired by the interferometer 14 is supplied to the main control system 22A.

[0044]On the other hand on the wafer buck 1, the wafer Y-axis drive stage 2 which can be freely driven to Y shaft orientations is laid, The wafer X-axis drive stage 3 which can be freely driven to an X axial direction on it is laid, Z leveling stage 4 is formed on it, and the wafer 5 is held by vacuum absorption on this Z leveling stage 4. The moving mirror 7 is fixed also on Z leveling stage 4, the position of the direction of X of Z leveling stage 4, the direction of Y, and the direction of theta is monitored by the interferometer 13 arranged outside, and the position information acquired by the interferometer 13 is also supplied to the main control system 22A. The main control system 22A controls the positioning operation of the wafer Y-axis drive stage

2, the wafer X-axis drive stage 3, and Z leveling stage 4 via the wafer drive 22B etc., and it controls operation of the whole device.
[0045]In order to take correspondence of the wafer-coordinates system specified by the coordinates measured by the interferometer 13 by the side of a wafer, and a Reticulum mark system specified by the coordinates measured by the interferometer 14 by the side of reticle, the reference mark board 6 is being fixed near the wafer 5 on Z leveling stage 4. Various reference marks are formed on this reference mark board 6. In these reference marks, the reference mark currently illuminated from the back side by the illumination light led to the Z leveling stage 4 side, i.e., a luminescent reference mark, is provided.
[0046]The reticle alignment microscopes 19 and 20 for observing simultaneously the reference mark on the reference mark board 6 and the mark on the reticle 12 are equipped above the reticle 12 of this example. In this case, when the deflection mirrors 15 and 16 for leading the detection light from the reticle 12 to the reticle alignment microscopes 19 and 20, respectively are arranged enabling free movement and an exposure sequence is started, under the instructions from the main control system 22A, The deflection mirrors 15 and 16 shunt with the mirror driving devices 17 and 18, respectively.
[0047]It equips with the oblique-incidence type multipoint focus position detection system of the conventional system explained to the projection aligner of the slit scan method of drawing 1 with reference to drawing 20 and drawing 21. However, the multipoint focus position detection system of this example has more number of a measure point than a conventional example, and arrangement of the measure point is devised. As drawing 2 (b) shows the pattern formation board 62A of this example corresponding to the conventional pattern formation board 62 of drawing 21 (b) and shows it to drawing 2 (b), The nine slit shape opening patterns 72-11 to 72-19 are formed in the 1st row of the pattern formation board 62A, and the nine opening patterns 72-12 to 72-59 are formed in the 2nd row - the 5th row, respectively. That is, 45 slit shape opening patterns are formed in the pattern formation board 62A in total.
The image of these slit shape opening patterns is aslant projected to the X-axis and a Y-axis on the exposure surface of the wafer 5 of drawing 1.

[0048]In drawing 2 (a) shows the exposure surface of the wafer 5 of the lower part of the projection optical system 8 of this example, and this drawing 2 (a), The pattern of the reticle 12 of drawing 1 is exposed in the exposure field 24 of a rectangle long in the direction of X inscribed in the circular lighting field 23 of the projection optical system 8, and the wafer 5 is scanned in the direction of Y to this exposure field 24 (scan). According to the multipoint focus position detection system of this example. The nine measure points AF11-AF19 of the 1st row extended in the direction of X of the direction upper part of Y of the exposure field 24, The image of a slit shape opening pattern is projected on the measure points AF21-AF29 of the

2nd row, the measure points AF31-AF39 of the 3rd row in the exposure field 24, the measure points AF41-AF49 of the 4th row of the direction bottom of Y of the exposure field 24, and the measure points AF51-AF59 of the 5th row, respectively.

[0049]Drawing 2 (c) shows the electric eye 69A of the multipoint focus position detection system of this example, the nine photo detectors 75-11 to 75-19 are arranged on this electric eye 69A at the 1st row, and the nine photo detectors 75-12 to 75-59 are arranged at the 2nd row - the 5th row, respectively. That is, 45 photo detectors are arranged in total by the electric eye 69A.

On each photo detector, the slit shape diaphragm (graphic display abbreviation) is arranged. Re-image formation of the image of the slit shape opening pattern projected at the measure points AF11-AF59 of drawing 2 (a), respectively on these photo detectors 75-11 to 75-59 is carried out. And on the electric eye 69A, the position of each image by which re-image formation was carried out vibrates in the direction of RD which is the cross direction of a diaphragm by carrying out rotational vibration of the light reflected in the exposure surface of the wafer 5 by the diaphragm corresponding to the hand-of-cut diaphragm 67 of drawing 20.

[0050]When the detecting signal of each photo detector 75-11 to 75-59 is supplied to the signal processor 71A and carries out synchronous detection of each detecting signal by the signal of rotational vibration frequency in the signal treating apparatus 71A, 45 focusing signals corresponding to the focusing position of each measure points AF11-AF59 on a wafer are generated, and the angle of inclination (leveling angle) and the average focusing position of an exposure surface of a wafer are computed like focusing signal predetermined of these 45 focusing signals] the after-mentioned. The leveling angle and focusing position which were these-measured are supplied to the main control system 22A of drawing 1, and the main control system 22A, Based on the leveling angle and focusing position which were supplied, setting out of the leveling angle of the wafer 5 and a focusing position is performed via the drive 22B and Z leveling stage 4.

[0051]Therefore, in this example, the focusing position of all the 45 measure points AF11-AF59 shown in drawing 2 (a) is measurable. However, in this example, as shown in drawing 3, the position of the point (henceforth a "sample point") which actually measures a focusing position in these 45 measure points according to the scanning direction of a wafer is changed. When scanning a wafer in the direction of Y to the exposure field 24, and in performing division destination reading like the after-mentioned as an example as shown in drawing 3 (a), odd-numbered measure point AF21 in the measure point of 25B, AF23, ..., AF29 and even-numbered measure point AF32 in the exposure field 24, AF34, ..., AF38 become a sample point. [of row / 2nd] When scanning a wafer in the direction of -Y to the exposure field 24, and in performing division destination reading like the after-mentioned as shown in drawing 3 (b), odd-numbered measure point AF41 in the measure point of 25D, AF43, ..., AF49 and even-numbered measure point AF32 in the exposure field 24, AF34, ..., AF38 become a sample point. [of row / 4th]

[0052]The measuring result of the focusing position at the time of slit scan exposure, In order to change one by one according to the moving coordinate of the stage by the side of a wafer, the measuring result of these focusing positions is memorized by the memory storage within the main control system 22A of drawing 1 as a two-dimensional map which consists of coordinates of the scanning direction of a stage, and coordinates of the measure point of a non-scanning direction. The focusing position and leveling angle of a wafer at the time of exposure are computed using the measuring result memorized in this way. And when actually driving Z leveling stage 4 of drawing 1 and setting up the focusing position and leveling angle of an exposure surface of a wafer, operation of Z leveling stage 4 is controlled by open loop control according to a measuring result. In this case, exposure in the exposure field 24 is performed based on the result measured beforehand. Namely, as shown in drawing 4 (a), the 2nd row of measurement of the focusing position of the field 26 on a wafer is performed by the predetermined sampling point of the measure point of 25B, As shown in drawing 4 (b) after that, when the field 26 on a wafer reaches in the exposure field 24, based on the measuring result in drawing 4 (a), focusing of the field 26 on a wafer and leveling control are performed.

[0053]Drawing 5 shows Z leveling stage 4 and this control system of this example, the top face member of Z leveling stage 4 is supported via the three fulcrums 28A-28C in this drawing 5 on the bottom member, and each fulcrums 28A-28C can be expanded now and contracted in a focusing direction, respectively. By adjusting the amount of elasticity of each fulcrums 28A-28C, angle-of-inclination theta_Y of the focusing position of the exposure surface of the wafer 5 on Z leveling stage 4 and a scanning direction and angle-of-inclination theta_X of a non-scanning direction can be set as a desired value. Near each fulcrums 28A-28C, the amount of displacement of the focusing direction of each fulcrum is attached to the height sensors 29A-29C measurable with resolution of about 0.01 micrometer, respectively. The highly precise mechanism as a positioning mechanism to a focusing direction (Z direction) in which a stroke is longer may be formed independently.

[0054]in order to control leveling operation of Z leveling stage 4, the main control system 22A supplies angle-of-inclination theta_Y which should set up angle-of-inclination theta_X which resembles the filter parts 30A and 30B every moment, and changes to them, respectively, and which should set up a non-scanning direction, and a scanning direction. The filter parts 30A and 30B supply the angle of inclination produced by filtering with filter characteristics different, respectively to the operation part 31, and the main control system 22A supplies the coordinates W of the field made into the exposure object on the wafer 5 (X, Y) to the operation part 31. The operation part 31 supplies the information on the amount of displacement which should be set as the actuators 32A-32C based on the coordinates W (X, Y) and two angles of inclination. The information on the present height of the fulcrums 29A-29C is also supplied to each actuators 32A-32C from the height sensors 29A-29C, respectively, and each actuators 32A-32C set the height of the fulcrums 29A-29C as the height set as the operation part 31, respectively.

[0055]By this, although the angle of inclination of the scanning direction of the exposure surface of the wafer 5 and the angle of inclination of a non-scanning direction are set as a desired value, respectively, In this case, by difference of the characteristic of the filter parts 30A and 30B, the response frequency fm of leveling of a scanning direction Hz is more highly set up from the speed of response fn of leveling of a non-scanning direction [Hz . The speed of response fn of leveling of 10 Hz and a non-scanning direction of the response frequency fm of leveling of a scanning direction is 2 Hz as an example.

[0056]If the position by which the fulcrums 28A, 28B, and 28C are arranged is called driving point tangent line1, tangent line2, and tangent line3, respectively, the driving points tangent line1 and tangent line2 are arranged on 1 straight line parallel to a Y-axis, and driving point tangent line3 is located on vertical 2 bisectrices with the driving points tangent line1 and tangent line2. And when the slit shape exposure field 24 by a projection optical system assumes that it is located on shot region SA_{ij} on the wafer 5, in this example. When performing leveling control of the wafer 5 via the fulcrums 28A-28C, the focusing position of the shot region SA_{ij} does not change. Therefore, it is carried out in the form which leveling control and focus control separated. Setting out of the focusing position of the exposure surface of the wafer 5 is performed when only the same quantity displaces the three fulcrums 28A-28C.

[0057]Next, it explains to details per leveling operation of this example, and focusing operation. First, the method of computing the angle of inclination for leveling and the focusing position for focusing is shown.

(A) As shown in computing method drawing 4 of an angle of inclination, in the measure point of each sequence, the Y coordinate of the n-th sample point of X_m and a scanning direction is made into Y_n for the X coordinate of the m-th sample point of a non-scanning direction, The value of the focusing position measured in the sample point of X coordinate X_m and Y coordinate Y_n is expressed with AF (X_m, Y_n). The sampling number of M and a scanning direction is set to N for the sample number of a non-scanning direction, and the next operation is performed. However, peace operation sigma_m expresses the sum to 1-M about the subscript m.

[0058]

SX sigma $_m X_m$ and SX2 sigma$_m X_m^2$, SMZ sigma $_m$AF (X_m, Y_n), and SXZ sigma $_m$ (AF (X_m, Y_n) and X_m) (5)

Similarly, peace operation sigma$_n$ performs the next operation as a thing showing the sum to 1-N about the subscript n.

SY sigma $_n Y_n$ and SY2 sigma$_n Y_n^2$, SNZ sigma $_n$AF (X_m, Y_n), and SYZ sigma $_n$ (AF (X_m, Y_n) and Y_n) (6)

[0059]And the next operation is performed using (5) types and (6) types.

An=(SX-SMZ-M-SXZ) (SX^2-M-SX2) (7)

Am=(SY-SNZ-N-SYZ) (SY^2-N-SY2) (8)

next, every -- it asking for the angle of inclination AL (Y_n) of the non-scanning direction (the direction of X) in the n-th sample point of a scanning direction by the least squares approximation, and from An, every -- from Am, it asks for the angle of inclination AL (X_m) of the scanning direction (the direction of Y) in the m-th sample point of a non-scanning direction by the least squares approximation. Then, angle-of-inclination theta$_X$ of a non-scanning direction and angle-of-inclination theta$_Y$ of a scanning direction are calculated by the following equalizing processings.

theta$_X$=(sigma$_n$ AL (Y_n))/N (9)

theta$_Y$= (sigma$_m$ AL (X_m)) (10)

[0060](B) There are an equalizing processing method and the maximum minimum detection system in the method of computing a focal position computation method focusing position, and compute a focusing position by the maximum minimum detection system in this example. By an equalizing processing method, the focusing position <AF> as the whole exposure surface of the wafer 5 is calculated from a following formula using value AF (X_m, Y_n) of an above-mentioned focusing position for reference.

<AF> (sigma$_n$sigma$_m$AF (X_m, Y_n))/(M-N) (11)

[0061]Next, in the maximum minimum detection system, the function showing the maximum and the minimum is made into Max() and Min(), respectively, and focusing position AF' as the whole exposure surface of the wafer 5 is calculated from a following formula.

AF' (Max(AF (X_m, Y_n)) +Min(AF (X_m, Y_n)) /2 (12))

And as shown in drawing 4 (b), when the measured field 26 arrives at the exposure field 24. (9) Based on detection result theta$_X$ of a formula, (10) types, and (12) types, theta$_Y$, and AF', the three fulcrums 28A-28C of drawing 5 drive with an open loop on the basis of the measuring result of the height sensors 29A-29C, respectively. Concretely, autofocus control is performed by driving simultaneously the three fulcrums 28A-28C, and auto leveling control is performed so that the focusing position in the exposure field 24 shown in drawing 5 may not change.

[0062]In drawing 5, the interval of the direction of X of the central point of the exposure field 24, and the fulcrums 28A and 28B Namely, X_1, The interval of the direction of X of the central point of the exposure field 24, and the fulcrum 28C X_2, The interval of Y_1 and the direction of Y of the central point of the exposure field 24 and the fulcrum 28B is made into Y_2 for the interval of the direction of Y of the central point of the exposure field 24, and the fulcrum 28A, Based on the result of angle-of-inclination theta_X of a non-scanning direction, displacement of an opposite direction is given to the fulcrums 28A and 28B and the fulcrum 28C by a ratio with $X_1:X_2$, respectively, Based on the result of angle-of-inclination theta_Y of a scanning direction, displacement of an opposite direction is given to the fulcrum 28A and the fulcrum 28B by a ratio with $Y_1:Y_2$, respectively.

[0063]In the above-mentioned approach, since a focusing position and an angle of inclination change every moment according to an exposure device, it is necessary to amend the measurement value of a actual focusing position. Drawing 6 (a) shows the state where the focusing position and angle of inclination of ****** are measured in the measure point (AF point) of a certain focusing position, [the whole field 26 on the exposure surface 5a of a wafer In the state of drawing 6 (a), the drive quantity <tangent line1>, <tangent line2>, and <tangent line3> of a focusing direction presuppose that it is 0 (reference position), respectively. of the fulcrum at each driving points tangent line1-tangent line3 of drawing 5] And as the field 26 shows drawing 6 (b), when it reaches at the exposure point in an exposure field, these drive quantity is set up, respectively for exposure, without <tangent line1> a, <tangent line2> b, and <tangent line3> c. In this case, although only deltaF is changing compared with the case of drawing 6 (a), the focusing position of the field 26A currently measured in the measure point (AF point) of the focusing position, Since the influence of the drive quantity in each driving points tangent line1-tangent line3 is included in the variation of this deltaF, to next expose the field 26A, it is necessary to perform leveling and focusing in the form which amends the drive quantity of each driving points tangent line1-tangent line3 in the state of drawing 6 (b).

[0064]Namely, the angle of inclination of the focusing position measured about the field 26, and the direction of X, and the angle of inclination of the direction of Y, respectively as F_1, theta_{1X}, and theta_{1Y}, The angle of inclination of the focusing position measured about the field 26A and the direction of X and the angle of inclination of the direction of Y are made into F_n', theta_{nX}', and theta_{nY}', respectively. When the interval of the direction of X of the measure point

(AF point) of a focusing position and an exposure point and the direction of Y is set to delta X and delta Y, respectively, correction amount deltaF1 of a focusing position is as follows.
deltaF1=-F_1-theta$_{1X}$, delta X-theta $_{1Y}$, and deltaY (13)

[0065]When the correction amount deltaF1 is used, value F_n, theta$_{nX}$, and theta$_{nY}$ after each amendment of the angle of inclination of the focusing position measured about the field 26A and the direction of X and the angle of inclination of the direction of Y are as follows.
F_n=F_n' deltaF1 (14)
theta$_{nX}$=theta$_{nX}$'-theta$_{1X}$ (15)
theta$_{nY}$=theta$_{nY}$'-theta$_{1Y}$ (16)
It is necessary to manage a response so that it may not follow to the uneven side of the high frequency of the exposure surface of the wafer 5. Namely, since the response corresponding to a stage position is required also when the scan speed of the wafer 5 changes, The mechanism in which manage the focusing position and angle of inclination which were measured with the numerical filter for Fast Fourier Transform (FFT), or the servo gain of the actuator of the three fulcrums 28A-28C of drawing 5 is changed according to speed is used. However, the numerical filter for FFT needs a preliminary scan, and since a servo gain has phase lag, the mechanism in consideration of these is required.

[0066](C) a servo gain flexible method -- here explains per which changes the servo gain of the actuator of the three fulcrums 28A-28C of drawing 5 according to speed] example of a method. When response frequency in case the scan speed of a wafer is V beta is set to nu, the transfer function G (s) is expressed as follows.
G(s)=1/(1+Ts) (17)
however, T 1 (2pinu) and s 2pifi -- it comes out.

[0067]From the analysis result, when scan speed V beta was 80 mm s, as for the response frequency nu of the non-scanning direction, 2 Hz was the optimal, and it found that 10 Hz was the optimal for the response frequency nu of the scanning direction. However, when unevenness of the exposure surface of a wafer is expressed with the sine wave of the pitch p and the length of the scanning direction of each shot region on a wafer is made into L_0, the frequency f in (17) types is as follows.
f=(V beta) L_0-(L_0/p) =(V beta) p (18)
Therefore, since the frequency f will change if scan speed V beta changes, it is necessary to newly ask for the optimal response frequency nu. Thus, a servo gain is determined from the response frequency nu for which it asked.

[0068](D) numerical filtering method -- since the pitch p of the unevenness here on the exposure surface of a wafer is a function depending on a stage position, if the sampling of a focusing position is performed by a datum reference synchronizing with a stage position, control independent of scan speed V beta will be attained. that is, in order to give the filtering effect equivalent to the transfer function G (s) with a position function, inverse Fourier transform of the transfer function G (s) is carried out, position function F(x) is calculated, and numerical filtering is performed using this position function F(x). An example of transfer function [of the response frequency nu G (s) is concretely shown in drawing 7 (a), and position function F(x) corresponding to it is shown in drawing 7 (b). However, it is necessary to take run-up scan distance, and at the time of numerical filtering, when not performing this, phase lag arises.

[0069]Also in which method of an above-mentioned servo gain flexible method and the numerical filtering method, a response is managed by phase lag and the filtering effect. Phase lag (time lag) is a time lag which exists between the signal corresponding to the focusing position made into the target shown with the curve 37A of drawing 15 (c), and the signal corresponding to the focusing position which is shown with the curve 38A, and which was measured actually. The filtering effect is that only the specified quantity makes amplitude of a actual focusing position small to a target focusing position, as the curves 37B and 38B of drawing 15 (d) show.

[0070]As mentioned above, in this example, when performing exposure to each shot region of a wafer, the run-up scan which is a preliminary scan may be performed. Then, the setting method of the run-up scan distance is explained. Drawing 8 (a) shows the scan method in the case of exposing the pattern of reticle to next shot region SA_{12} and SA_{13} one by one, after finishing exposure of shot region SA_{11} on a wafer. After it scans a wafer in the direction of -Y and the exposure to shot region SA_{11} on a wafer finishes in this drawing 8 (a), A wafer is aslant moved to the X-axis and a Y-axis between acceleration-and-deceleration period T_{W1}, and the neighborhood of the lower end of the next shot region SA_{12} is arranged to the exposure field of a projection optical system. After the exposure to the first shot region SA_{11} finishes, while moving near the lower end of the next shot region SA_{12}, movement of interval deltaL is performed in the direction of Y. In the telophase of the acceleration-and-deceleration period T_{W1}, movement in the direction of Y of a wafer is started.

[0071]Between subsequent establishment (setting) period T_{W2}, the scan speed of a wafer reaches about V beta, and exposure of the pattern of the reticle to shot region SA_{12} is performed between exposure time T_{W3} following it. Acceleration-and-deceleration period T_{W1}, establishment period T_{W2}, and exposure time T_{W3} by the side of a wafer in this case are shown in drawing 8 (c), and acceleration-and-deceleration period T_{R1}, establishment period T_{R2}, and exposure time T_{R3} by the side of reticle are shown in drawing 8 (b). In the reticle side, since it is not necessary to move to the next shot region like drawing 8 (a), movement of the stage by the side of reticle is reciprocating movement in alignment with a Y-axis. In the wafer side, as shown in drawing 8 (c), the sampling of the focusing position by a multipoint focus position detection system is started from t_s at the time of the grade which shifts to establishment period T_{W2} from acceleration-and-deceleration period T_{W1}.

[0072]In this example, since the response at the time of leveling and focusing is managed by phase lag and the filtering effect, the starting point when starting the sampling of a focusing position on a wafer changes with situations. For example, as what synchronizes a sampling with a stage position, supposing it performs numerical filtering, a sampling start position will be determined in the following procedure.

[0073]First, the transfer function G (s) is given like drawing 7 (a), and from this transfer function G (s), position function F(x) of drawing 7 (b) is calculated by inverse Fourier transform, and it asks for length deltaL from the starting point of this position function F(x) to a zero crossing point. This length deltaL is equal to movement magnitude deltaL to the direction of Y at the time of moving aslant because of the exposure to the next shot region SA_{12}, as shown in drawing 8 (a).

[0074]To acceleration-and-deceleration period T_{R1} of reticle, since acceleration-and-deceleration period T_{W1} of a wafer is small, time $(T_{R1}-T_{W1})$ turns into waiting time by the side of a wafer. in this case, deltaL -- < (V beta) $(T_{R1}-T_{W1})$ -- although it does not become the fall of a throughput at the time of **, it becomes the fall of a throughput at the time of deltaL> (V beta) $(T_{R1}-T_{W1})$ and **. delta Y delta L- (V beta) $(T_{R1}-T_{W1})$ and length deltaY come out of and expressed are good as a fixed function, if the same filtering effect as the transfer function G (s) is acquired even if it processes as phase lag. By performing these filtering, the effect of reducing the influence of the air fluctuation to a multipoint focus position detection system and the control error of a multipoint focus position detection system is also expectable.

[0075]Next, arrangement of the sample point in the measure point of the multipoint focus position detection system in the projection aligner of the slit scan exposure system of this example is considered. First, among the measure points AF11-AF59 according [on drawing 2 (a) and] to a multipoint focus position detection system, When using the measuring result of the focusing position of the measure points AF31-AF39 in the slit shape exposure field 24 (i.e., when making the measure points AF31-AF39 into a sample point), control by the same "the exposure position controlling method as the conventional stepper's case is performed.Since the scan of the wafer of this example is performed in the direction of Y, or the direction of -Y, it is arranging the sample in a measure point before a scanning direction to the exposure field 24, and prediction control, time sharing leveling measurement, measurement value equalization, etc. are attained.

[0076]Prediction control means choosing a sample point from the measure points AF41-AF49 before a scan, AF51 - AF59, when scanning a wafer [like in the direction of -Y to the exposure field 24 at drawing 2 (a). By performing prediction control, the following error over actual response frequency becomes |1-G(s) | to the transfer function G (s) of an autofocusing mechanism and an auto leveling mechanism. However, since phase lag and a filtering error factor are contained in this following error, phase lag can be removed if prediction control is performed. Since this error is 1-G[| (s) |, about 4 times as much communicative competence can be given.

[0077]Drawing 9 (a) shows the curve 39A corresponding to the focusing position made into the target at the time of performing the same exposure position control as usual, and the curve 38B corresponding to the actually set-up focusing position, Drawing 9 (b) showed the curve 40A corresponding to the focusing position made into the target at the time of performing prediction control, and the curve 40B corresponding to the actually set-up focusing position, and the phase has shifted in exposure position control. Therefore, the difference Fa of the target position in exposure position control and a flattery position will be about 4 times the difference Fb of the target position in prediction control, and a flattery position. Therefore, in prediction control, about 4 times as much communicative competence can be given.

[0078]However, as already stated, since about 10 Hz is suitable in a scanning direction (position control method), when the response frequency of auto leveling performs prediction control, the filtering response of about 2.5 Hz may be sufficient as it in a scanning direction. When a numerical filter or a control gain performs this filtering, the scan speed of a wafer shall be 80 mm and the run-up scan length about 5(**80/)(2pi*2.5) mm is needed before exposure. The focus error by both the controlling method is shown below.

[0079]Therefore, like the case of drawing 17 the cycle of a periodic bend of the scanning direction of shot region SA_{ij} on a wafer, It bends as a value of a ratio with the width of a scanning direction, and expresses with the parameter F, and the focus error in each measure point in case there is the periodic bend is expressed with the absolute value of the average value of the error of the focusing position in each measure point, and one third of the sums of the amplitude of the error of a focusing position. The amplitude of a periodic bend of the bend parameter F is standardized to 1, and error parameter S which shows the maximum of the focus errors in these each measure point in case a bend parameter is F is expressed as a ratio to the bend parameter F.

[0080]When exposure position control is performed, the response frequency fm of leveling of a scanning direction drawing 10 (a) 10 Hz, Expressing error parameter S to the bend parameter F in case the response frequency fn of leveling of a non-scanning direction is 2 Hz, curvilinear A9 and B9 show error parameter in a non-scanning direction] S, and both the curves A10 and B10 of both show error parameter S in a scanning direction. On the other hand, when prediction control is performed, the response frequency fm of leveling of a scanning direction drawing 17 (b) 2.5 Hz, Expressing error parameter S to the bend parameter F in case the response frequency fn of leveling of a non-scanning direction is 0.5 Hz, the curves A11 and B11 show error parameter in a non-scanning direction] S, and both the curves A12 and B12 of both show error parameter S in a scanning direction.

[0081]In order to improve a response, it is good, but it is not suitable to remove phase lag by prediction control as mentioned above, when reducing a response. However, prediction control has much flexibility by software, and can also perform time equalization as shown by drawing 11, and prediction setting out of the measure point of the focusing position in the time of an exposure start. That is, in drawing 11 (a), a focusing position is detected only the length of width deltaL in a front sample point (AF point) to the scanning direction of a multipoint focus position detection system to a certain field 26B on the exposure surface 5a of a wafer. And as shown in drawing 11 (b), when the field 26B reaches at an exposure point, the information on the focusing position detected in the range of width deltaL is equalized, and leveling and focusing are performed with high precision.

[0082]As shown in drawing 11 (c), by the exposure position controlling method by the case where a measure point and an exposure point are equal. Even if the exposure surface 5a of a wafer has the level difference part 26C, as shown in drawing 11 (d), field (focal side) AFP made into a focal object only goes up gradually, and exposure is performed in the state where it was defocused at the level difference part 26C. By on the other hand, the case where the measure point and the exposure point are separated by the prediction controlling method as shown in drawing 11 (e). If the exposure surface 5a of a wafer has the level difference part 26D, as beforehand shown in drawing 11 (f) according to the level difference, exposure will be performed in the state where it focused, by going up focal field AFP gradually at the level difference part 26D.

[0083]It has not only the prediction controlling method but the usual exposure position controlling method, and it is desirable to use the two controlling methods as a selectable system. Since the auto-focusing and the auto leveling mechanism of this example have the above functions, in order to actually control the exposure surface of a wafer, the method of controlling three kinds which consists of exposure position control, full prediction control, and ** division destination reading control can be considered. Below, it explains to these three kinds of controlling method per details.

(F) Perform control of the focusing position of the exposure surface of a wafer, and a leveling angle using the value of the focusing position produced by measuring at the time of exposure regardless of the response performance of auto-focusing and an auto leveling mechanism at all by the exposure position controlling method this gentleman formula. Namely, as shown in drawing 12 (a), also let 25Cthe 3rd row odd-numbered measure point in the exposure field 24 be a sample point to the exposure field 24 in a scanning direction (the direction of Y) by making 25Bthe 2nd row even-numbered measure point of a near side into the sample point 41. And the 2nd row of the 3rd row of leveling control of the scanning direction of the exposure surface of a wafer is performed from the measurement value of the focusing position in the sample point of 25C with the measurement value of the focusing position in the sample point of 25B.

[0084]It 2nd row 25B Reaches, the 3rd row of the inclination to a non-scanning direction is calculated by a least-squares-approximation method from the measurement value of the focusing position in the sample point of 25C, and leveling control of a non-scanning direction is performed. The measurement value of the focusing position in the measure point of the 3rd row in the exposure field 24 is also used for focus control, and it performs focus control. As shown in drawing 12 (b), when the scanning direction of a wafer is the direction of -Y, a sample point 3rd row 25C Reaches, and is chosen from the measure point of 25D the 4th row. In this method, although control is the easiest, there is inconvenience that flattery accuracy will change with the scanning speed of a wafer, etc. It 2nd row 25B Reaches and the 3rd row of the calibration of the focusing position in each measure point of 25C is required.

[0085](G) receiving the exposure field 24 in the full prediction controlling method this gentleman type, as shown in drawing 12 (c) -- a scanning direction -- a near side -- measure the 1st row of all the values the 1st row of of the focusing position in the sample point of 25A before exposure beforehand by making all the measure points of 25A into a sample point. And equalizing processing and filtering processing are performed, phase lag is expected, it is open at the time of exposure, and auto-focusing and an auto leveling mechanism are controlled. Namely, the 1st row of the measurement value of the focusing position in each sample point of 25A is memorized, inclination to a scanning direction is computed from the value of the focusing position measured on the time-axis, and leveling control of a scanning direction is performed by open control at the time of exposure.

[0086]In parallel to it, the 1st row of the inclination to a non-scanning direction is calculated by a least-squares-approximation method from the measurement value of the focusing position in each sample point of 25A, and leveling control of a non-scanning direction is performed by open control. Since it is prediction, equalization on a time-axis is also possible. The 1st row of the measurement value of the focusing position in each sample point of 25A is memorized, and focal doubling is performed by open control at the time of exposure. As shown in drawing 12 (d), when the scanning direction of a wafer is the direction of -Y, the 5th row of all the measure points of 25E is chosen as a sample point.

[0087]In this method, since nine sample points can secure the 1st row in 25A, there is much amount of information and precision improvement is expectable. Since a sample point is one line, there is an advantage which does not need a calibration that management of a response can both be performed. On the other hand, when the 1st row is directly measured about the sample point of 25A, in order to expose the end of each shot region, the distance (run-up scan length) which should be scanned becomes long, and there is inconvenience to which a throughput falls. Since it is open control, there is also inconvenience that the check by a multipoint focus position detection system cannot be performed.

[0088](H) In the division destination reading controlling method this gentleman type, as shown in drawing 12 (e), also let 25Cthe 3rd row even-numbered measure point in the exposure field 24 be a sample point to the exposure field 24 in a scanning direction (the direction of Y) by making 25Bthe 2nd row odd-numbered measure point of a near side into a sample point. And it 2nd row 25B Reaches and the 3rd row of all the values of the focusing position are beforehand measured before exposure in the sample point of 25C. Then, equalizing processing and filtering processing are performed, phase lag is expected, and it controls by open control at the time of exposure. Namely, the 2nd row of 25B and the measurement value [in / the 3rd row / the sample point of 25C of a focusing position are memorized, inclination to a scanning direction is computed from the value of the focusing position measured on the time-axis, and leveling of a scanning direction is performed by open control at the time of exposure.

[0089]The 2nd row of the inclination to a non-scanning direction is calculated by a least-squares-approximation method from the measurement value of 25B and a focusing position [in / the 3rd row / the sample point of 25C , and leveling of a non-scanning direction is performed by open control. Since it is prediction, equalization on a time-axis is also possible. The 2nd row of 25B and the measurement value in the 3rd row the sample point of 25C of a focusing position are memorized, and focal doubling is performed by open control at the time of exposure. As shown in drawing 12 (f), when the scanning direction of a wafer is the direction of -Y, a sample point 3rd row 25C Reaches, and is chosen from the measure point of 25D the 4th row.

[0090]In this method, since row 2nd 25B (or the 4th row 25D) is close to the exposure field 24, run-up scan distance for exposing the end of each shot region of a wafer can be lessened, and there is an advantage that management of a response can be performed. The check of the result at the time of exposure of having controlled the 3rd row of the exposure surface by open control from the measurement value of the focusing position in the sample point of 25C is possible. On the other hand, there is inconvenience that the 2nd row of the calibration of the focusing position in the sample point of 25B and the focusing position in the sample point of the 3rd row is required.

[0091]In the full prediction controlling method, as shown in drawing 13 (a) - (d), more exact auto-focusing and auto leveling control are performed by changing the sample point of under an exposure start and exposure and the focusing position just before exposure completion. Namely, as shown in drawing 13 (a), when shot region SA which should be exposed reaches the position of the interval D (it is the same as the width of the scanning direction of the exposure field 24) to the exposure field 24, Measurement of the focusing position by a multipoint focus position detection system is started from the exposure field 24 in the sample area 42 of the interval D. An example of the width D, i.e., the width of the scanning direction of the exposure field 24, is 8 mm. Then, as shown in drawing 13 (b), when the tip part of shot region SA contacts the exposure field 24, Leveling control of a scanning direction is performed based on the measurement value of the focusing position in the detection area 44 during two sample points on a wafer, and autofocus control is performed based on the measurement value of the focusing position in the detection area 45 which consists of one sample point.

[0092]Next, as shown in drawing 13 (c), when the tip part of shot region SA goes into the exposure field 24, Leveling control of a scanning direction is performed based on the measurement value of the focusing position in the detection area 44 during two sample points on a wafer, and autofocus control is performed based on the measurement value of the focusing position in the detection area 45 during two sample points. As shown in drawing 13 (d), when shot region SA comes to cover the exposure field 24, Based on the measurement value of the focusing position in the wrap detection area 44, leveling control of a scanning direction is performed in the exposure field 24, and autofocus control is performed based on the measurement value of the focusing position in the wrap detection area 45 in the exposure field 24.

[0093]On the other hand, also by the division destination reading controlling method, as shown in drawing 13 (e) - (h), more exact auto-focusing and auto leveling control are performed by changing the sample point of under an exposure start and exposure and the focusing position just before exposure completion. Namely, as shown in drawing 13 (e), when shot region SA which should be exposed reaches the position of interval D 2 (1 2 of the width of the scanning direction of the exposure field 24) to the exposure field 24, Measurement of the focusing position by a multipoint focus position detection system is started from the exposure field 24 outside in the sample area 43B of interval D 2 from the sample area 43A and the exposure field 24 of interval D 2 to the inside. Then, as shown in drawing 13 (f), when the tip part of shot region SA contacts the exposure field 24, Based on the measurement value of the focusing position in the wrap detection area 46, leveling control of a scanning direction is performed in the exposure field 24, and autofocus control is performed based on the measurement value of the focusing position in the detection area 47 which consists of one sample point.

[0094]Next, as shown in drawing 13 (g), when the tip part of shot region SA goes into the exposure field 24 only width D 2, Based on the measurement value of the focusing position in the wrap detection area 46, leveling control of a scanning direction is performed in the exposure field 24, and autofocus control is performed based on the measurement value of the focusing position in the detection area 47 of width D 2. As shown in drawing 13 (h), when shot region SA comes to cover the exposure field 24, Based on the measurement value of the focusing position in the wrap detection area 46, leveling control of a scanning direction is performed in the exposure field 24, and autofocus control is performed based on the measurement value of the focusing position in the wrap detection area 47 in the exposure field 24. Drawing 13 shows that run-up scan length (= D 2) is made to one half compared with the perfect predicting method in a division destination reading method.

[0095]In the above-mentioned example, in order to measure the focusing position of the multipoint of the exposure surface of a wafer, the multipoint focus position detection system which projects on a wafer the slit shape opening pattern image arranged in two dimensions is used. However, instead, the image of the pattern which is slit shape long and slender to a non-scanning direction may be projected on a wafer, and the one-dimensional focal position detection system which measures the focusing position of the whole non-scanning direction may be used. Even when measuring distribution of the two-dimensional focusing position on the exposure surface of a wafer using the focal position detection system of an image processing method, highly precise focusing and leveling can be performed by applying the same division destination reading as the above-mentioned example. Leveling operation of only a non-scanning direction may be performed in this example, without performing leveling operation of a scanning direction to the leveling error of a non-scanning direction, since the leveling error of a scanning direction is small so that drawing 17 may show.

[0096]Of course, various composition can be taken in the range which this invention is not limited to the above-mentioned example, and does not deviate from the gist of this invention.

[0097]

[Effect of the Invention In according to the 1st surface position setting device of this invention the projection aligner of a slit scan exposure system, The error by unevenness of the surface of a sensitized substrate, the measurement accuracy of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the exposure surface of a sensitized substrate can be doubled in parallel with high precision to the image surface of a projection optical system.

[0098]When the sensitized substrate is scanned via the substrate side stage and a multipoint measurement means samples the height of the sensitized substrate in two or more measure points by the datum reference of the substrate side stage, the angle of inclination of a scanning direction can be measured more to high degree of accuracy. In two or more measure points

when a multipoint measurement means becomes from two or more points in the field of this side at the time of a sensitized substrate being scanned to the inside of two or more points in a conjugate exposure region, and the conjugate exposure region of those about the illuminated field and projection optical system of specified shape, In measuring the height of the sensitized substrate, respectively, there is an advantage which can shorten the run-up scan distance at the time of the start of exposure by division destination reading control.
[0099]When a multipoint measurement means changes the position of two or more measure points to one shot region of a sensitized substrate one by one in the process in which the pattern of a mask is exposed one by one, For example, by using together division destination reading and full prediction, both leveling accuracy and a throughput are improvable. In
[according to the 2nd surface position setting device of this invention the projection aligner of a slit scan exposure system, The error by unevenness of the surface of a sensitized substrate, the measurement accuracy of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the focusing position of the exposure surface of a sensitized substrate can be correctly doubled to the image surface of a projection optical system.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings

[Drawing 1 It is a lineblock diagram showing the projection aligner with which one example of the surface position setting device by this invention was applied.

[Drawing 2 The top view showing the slit shape two-dimensional opening pattern image projected on the field to which (a) includes the exposure field by a projection optical system in an example, the figure in which (b) shows the opening pattern on the pattern formation board of a multipoint focus position detection system, and (c) are the figures showing the arrangement of the photo detector on an electric eye.

[Drawing 3 The figure showing a sample point in case (a) performs division destination reading in the example, and (b) are the figures showing the sample point in the case of performing division destination reading when scanning to an opposite direction.

[Drawing 4 The figure showing the case where (a) predicts a focusing position, and (b) are the figures showing the case where it exposes using the predicted focusing position.

[Drawing 5 It is a lineblock diagram showing the auto-focusing of an example, an auto leveling mechanism, and its control section.

[Drawing 6 It is an explanatory view of the correcting method of the measurement value of a focusing position.

[Drawing 7 (a) is a figure in which the response frequency nu shows the figure showing the transfer function in the case of being 10 Hz, and the position function acquired by (b) carrying out inverse Fourier transform of the transfer function of drawing 7 (a).

[Drawing 8 The timing chart at the time of the scan of reticle and (c of the figure showing the locus of a wafer in case (a) is exposed to an adjoining shot region, and (b)) are the timing charts at the time of the scan of a wafer.

[Drawing 9 The figure showing flattery accuracy in case (a) performs leveling and focusing by the exposure position controlling method, and (b) are the figures showing the flattery accuracy

in the case of performing leveling and focusing by the prediction controlling method.
[Drawing 10 The figure showing the calculation result of error parameter S to the bend parameter F when (a) uses the exposure position controlling method, and (b) are the figures showing the calculation result of error parameter S to the bend parameter F at the time of using the prediction controlling method.
[Drawing 11 (a) and the figure showing a focal field in case the explanatory view of the equalization effect in in (b) the prediction controlling method , (c), and (d) perform exposure position control, (e), and (f) are the figures showing the focal field in the case of performing prediction control.
[Drawing 12 (a) And the top view showing the sample point of a focusing position in case (b) performs exposure position control, (c) And the top view showing the sample point of a focusing position in case (d) performs full prediction control, (e), and (f) are the top views showing the sample point of the focusing position in the case of performing division destination reading control.
[Drawing 13 (a) The explanatory view of the method of controlling, in case - (d) is exposed by the full prediction controlling method, and (e) - (h) are the explanatory views of the method of controlling in the case of exposing by the division destination reading controlling method.
[Drawing 14 The figure showing a focus error in case (a) performs one-shot exposure, and (b) are the figures showing the focus error in the case of exposing with a slit scan exposure system.
[Drawing 15 The figure showing a focus error in case (a) performs autofocus control using the maximum and the minimum of a measurement value, The figure showing a focus error in case (b) performs auto-focusing using the average value of a measurement value, the figure in which (c) shows a time lag error, and (d) are the figures showing change of a servo gain.
[Drawing 16 It is a top view showing the state of performing exposure to the shot region on a wafer in a slit shape exposure field.
[Drawing 17 The figure showing the calculation result of error parameter S to the bend parameter F at the time of (a) making equal response frequency of a scanning direction, and response frequency of a non-scanning direction, and performing leveling control, (b) is a figure showing the calculation result of error parameter S to the bend parameter F at the time of making response frequency of a scanning direction higher than the response frequency of a non-scanning direction, and performing leveling control.
[Drawing 18 The figure showing the state where (a) performs autofocus control using the average value of a focusing position, and (b) are the figures showing the state of performing autofocus control using the maximum of a focusing position, and the average value of the minimum.
[Drawing 19 The figure showing the calculation result of error parameter S to the bend

parameter F when (a) performs autofocus control by equalizing processing further in the state of drawing 17 (a), (b) is a figure showing the calculation result of error parameter S to the bend parameter F at the time of performing autofocus control using the maximum of a focusing position, and the average value of the minimum in the state of drawing 17 (b) further.

[Drawing 20 It is a lineblock diagram showing the multipoint focus position detection system in the conventional stepper.

[Drawing 21 The top view showing the slit shape two-dimensional opening pattern image projected on the field to which (a) includes the exposure field by a projection optical system in drawing 20, The figure in which (b) shows the opening pattern on the pattern formation board of the multipoint focus position detection system of drawing 20, and (c) are the figures showing the arrangement of the photo detector on the electric eye of drawing 20.

[Description of Notations

2	Wafer Y-axis drive stage
4	Z leveling stage
5	Wafer
8	Projection optical system
10	Reticle Y drive stage
12	Reticle
22A	Main control system
24	A slit shape exposure field
62A	Pattern formation board
69A	Electric eye
71A	Signal processor
AF11-AF59	Measure point

[Translation done.]

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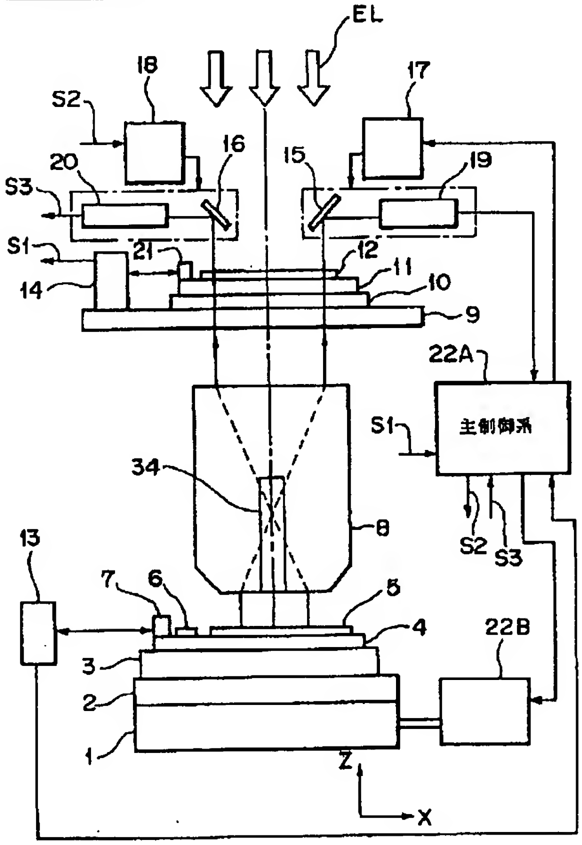
DRAWINGS

[Drawing 1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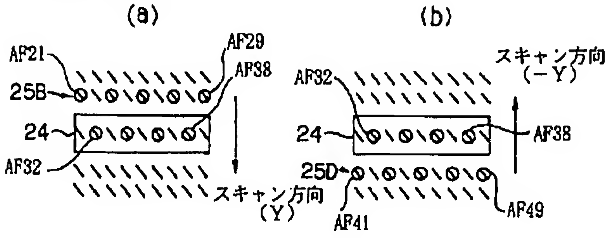
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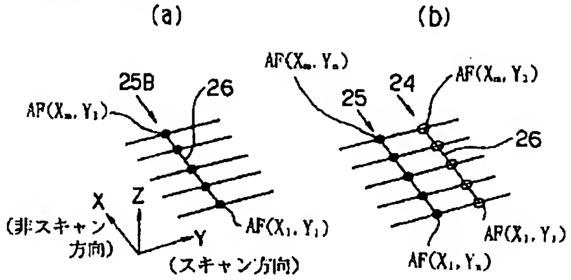
AF49

[Drawing 4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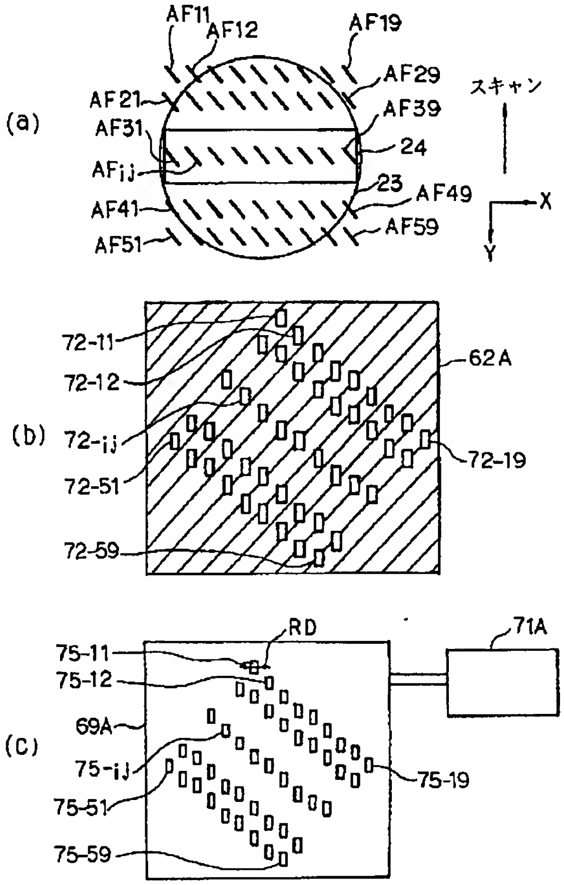
[Drawing 2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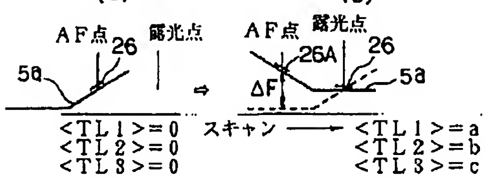
[Drawing 6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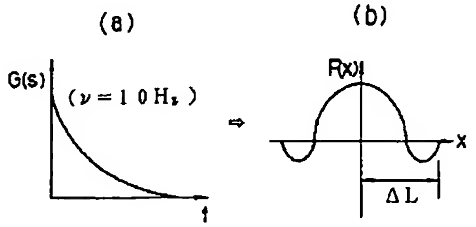
[Drawing 7



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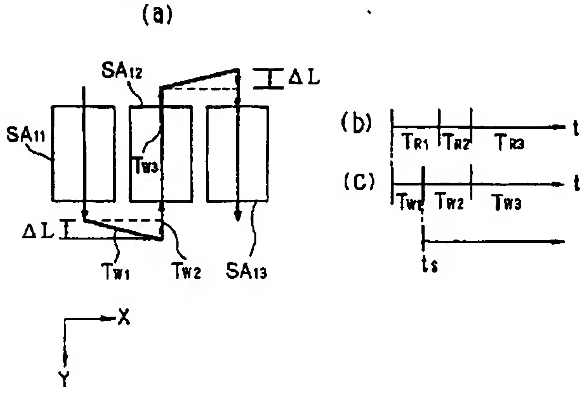
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t
ts

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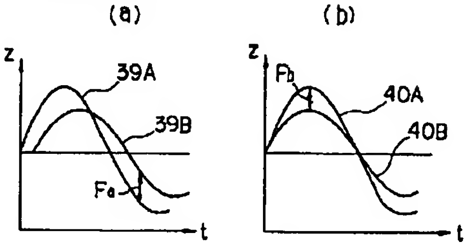

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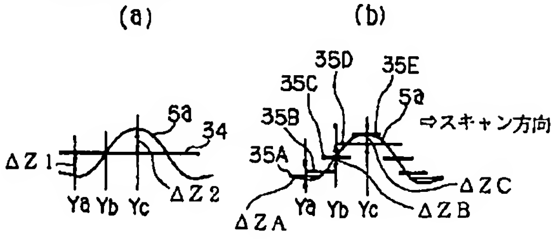
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(b)
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35C
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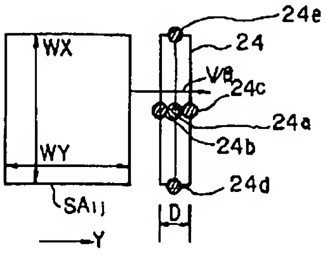
Yc
ΔZB

[Drawing 16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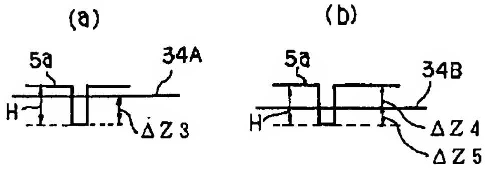
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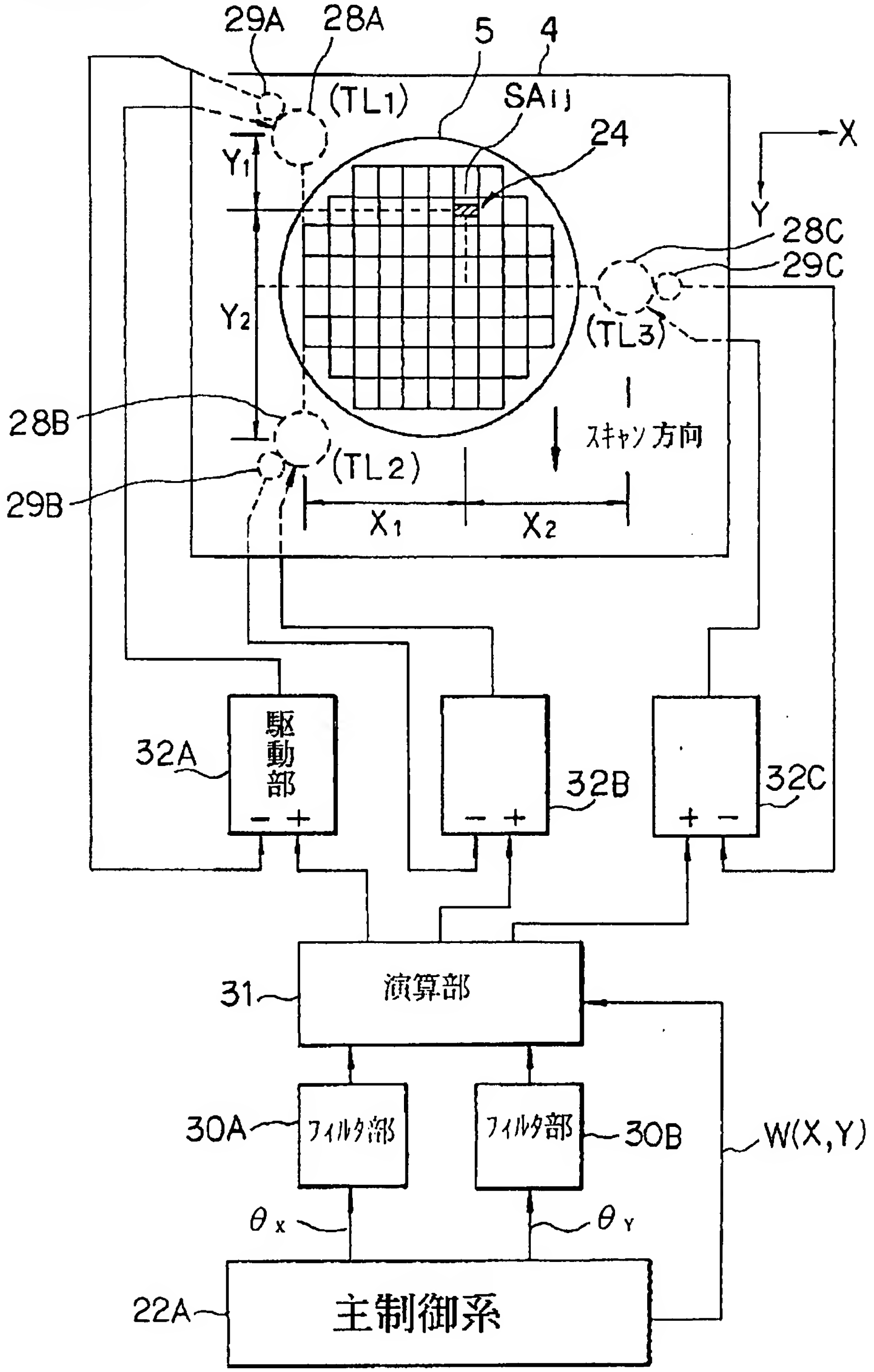
[Drawing 5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(TL2)
スキャン方向
X1
X2
駆動部
32A
− +
32B
− +
32C
+ −
31
演算部
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θY
22A
主制御系

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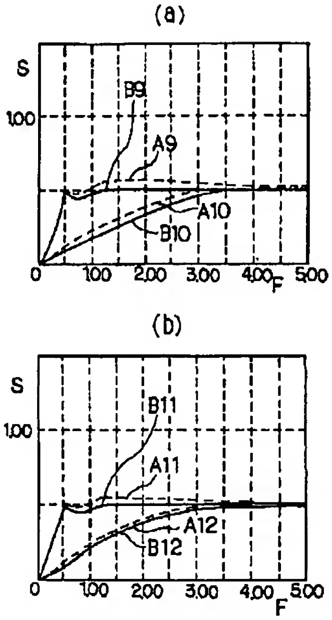

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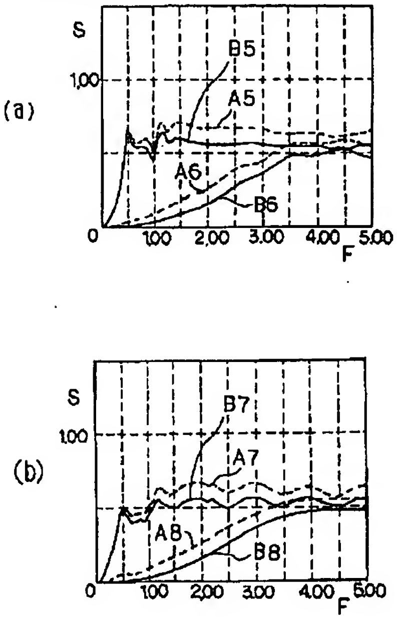

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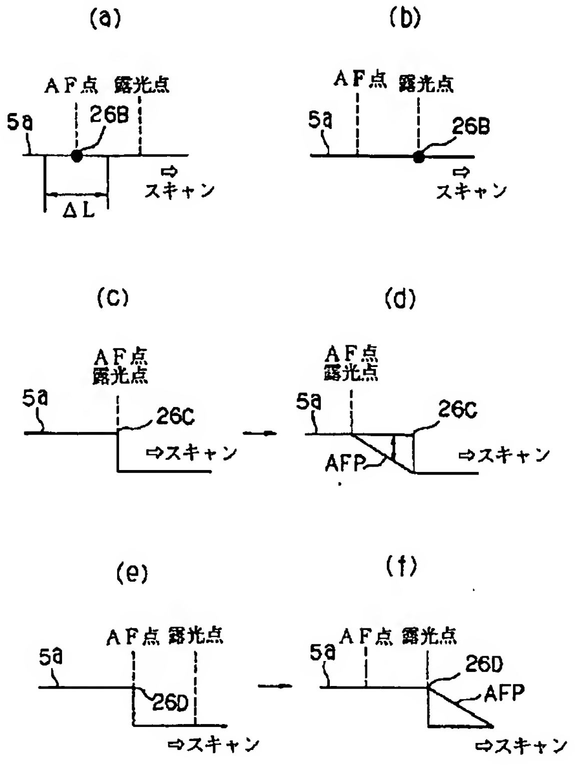
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(d)
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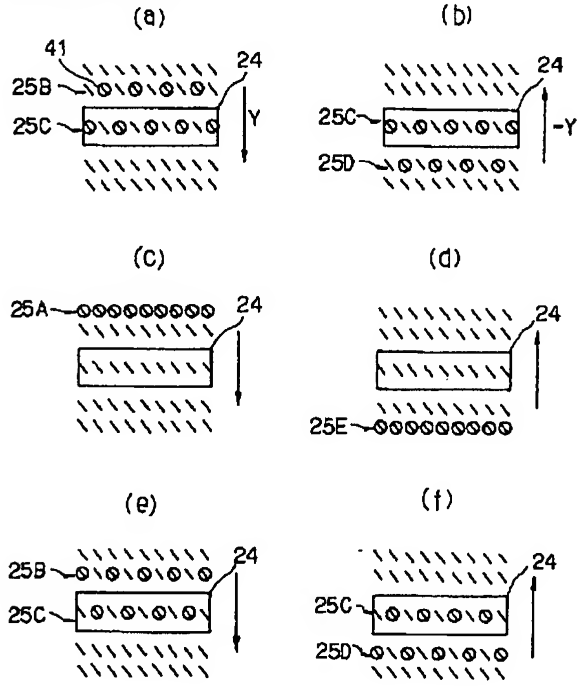
AFP
(e)
(f)
26D

[Drawing 12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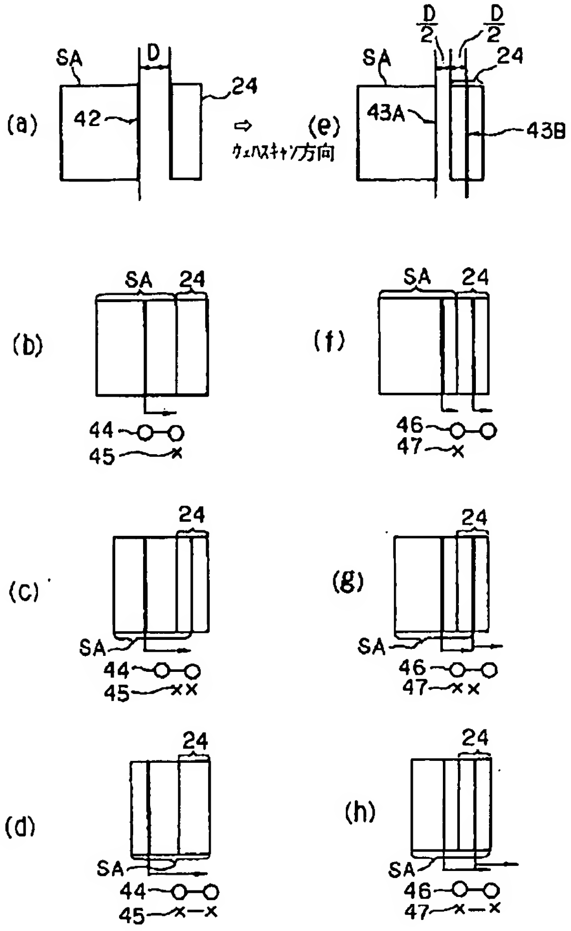
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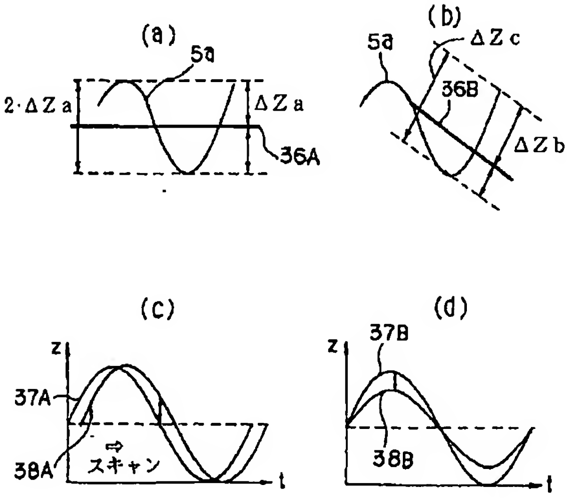
24
SA
46
47

[Drawing 15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⇨
スキャン
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(d)
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37B
38B
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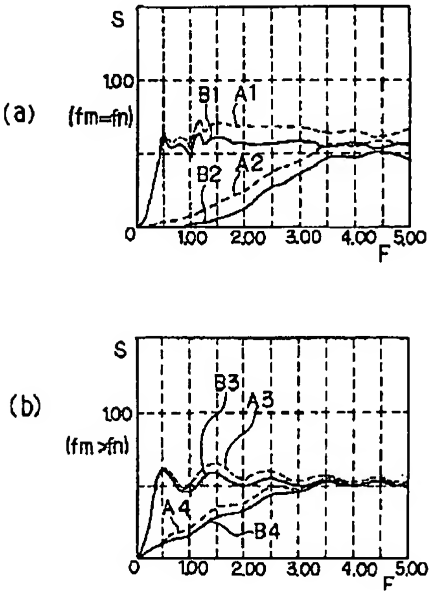
[Drawing 17



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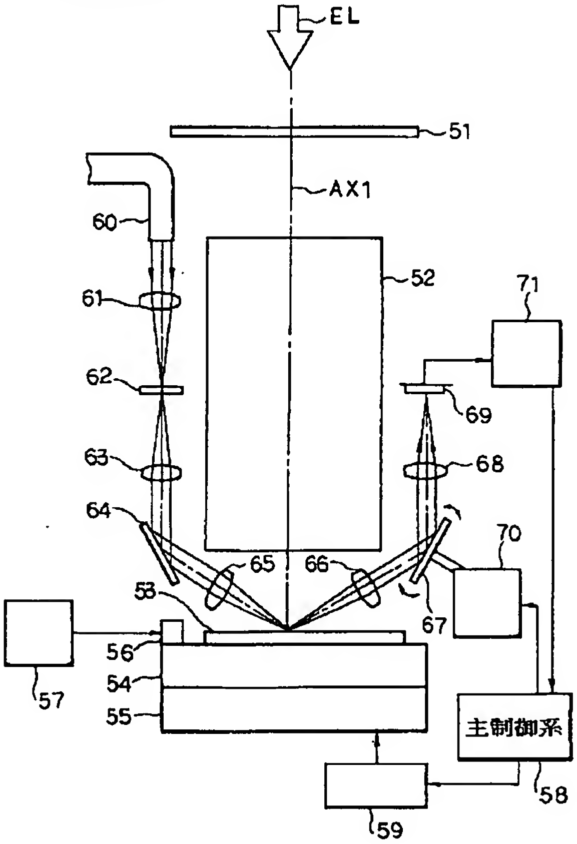
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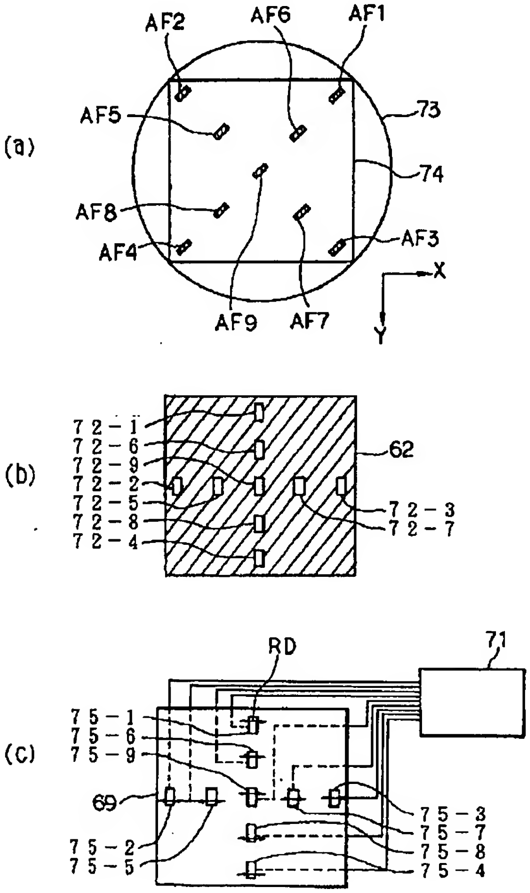
57
主制御系
58
59

[Drawing 21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AF1
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72-3
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(c)
RD
71
75-1
75-6
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69
75-2
75-5
75-3
75-7
75-8
75-4

[Translation done.]

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CORRECTION OR AMENDMENT

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[Section classification] The 2nd classification of the part VII gate
[Publication date March 23, Heisei 13 (2001.3.23)

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[Date of Publication October 7, Heisei 6 (1994.10.7)
[Annual volume number Publication of patent applications 6-2835
[Application number]Japanese Patent Application No. 5-67271
[The 7th edition of International Patent Classification

H01L 21/027

G03B 27/32

G03F 9/00
[FI

H01L 21/30 311 N

G03B 27/32 F

G03F 9/00 H
[Written amendment
[Filing date]June 14, Heisei 11 (1999.6.14)
[Amendment 1]
[Document to be Amended Specification
[Item(s) to be Amended The name of an invention
[Method of Amendment]Change
[Proposed Amendment

[Title of the Invention A device manufacturing method which uses a scanning exposure method, a surface position setting device, a scanning type exposure device, and said method
[Amendment 2]
[Document to be Amended Specification
[Item(s) to be Amended Claim
[Method of Amendment]Change
[Proposed Amendment
[Claim(s)

[Claim 1 An illumination-light study system which illuminates an illuminated field of specified shape by exposing light, and the mask side stage which scans a mask in which a pattern for exposure was formed to said illuminated field, It is a surface position setting device for being provided in an exposure device which has a projection optical system which projects a pattern of said mask in said illuminated field on a sensitized substrate, and the substrate side stage which scans said sensitized substrate synchronizing with said mask, and doubling an exposure surface of said sensitized substrate in parallel with the image surface of said projection optical system,

A multipoint measurement means which measures height of a direction parallel to an optic axis of said projection optical system of said sensitized substrate in two or more measure points including two or more points of a direction which crosses in the direction by which said sensitized substrate is scanned, respectively,

A calculating means which asks for difference of an angle of inclination between an exposure surface of said sensitized substrate, and the image surface of said projection optical system from a measuring result of this multipoint measurement means,

It is provided in said substrate side stage, and has an inclination setting-out stage which sets up an angle of inclination of a direction which intersects perpendicularly in an angle of inclination of the direction of said scan of said sensitized substrate, and the direction of said scan based on difference of said angle of inclination called for by said calculating means,

A surface position setting device making speed of response in case this inclination setting-out stage sets up an angle of inclination of the direction of said scan of said sensitized substrate differ from speed of response when setting up an angle of inclination of a direction which intersects perpendicularly towards said scan.

[Claim 2 The surface position setting device according to claim 1 when said multipoint measurement means is scanned [said sensitized substrate via said substrate side stage, wherein it samples height of said sensitized substrate in said two or more measure points by a datum reference of said substrate side stage.

[Claim 3 In two or more measure points when said multipoint measurement means becomes from two or more points in a field of this side at the time of said sensitized substrate being scanned to inside of two or more points in a conjugate exposure region, and said conjugate exposure region about an illuminated field and said projection optical system of said specified shape, The surface position setting device according to claim 1 or 2 measuring height of said sensitized substrate, respectively.

[Claim 4 The surface position setting device according to claim 1, wherein said multipoint measurement means changes a position of two or more of said measure points to one shot region of said sensitized substrate one by one in a process in which a pattern of said mask is exposed one by one.

[Claim 5 An illumination-light study system which illuminates an illuminated field of specified shape by exposing light, and the mask side stage which scans a mask in which a pattern for exposure was formed to said illuminated field, It is a surface position setting device for being provided in an exposure device which has a projection optical system which projects a pattern of said mask in said illuminated field on a sensitized substrate, and the substrate side stage which scans said sensitized substrate synchronizing with said mask, and doubling height of an exposure surface of said sensitized substrate with the image surface of said projection optical system,

A height measurement means to measure height of a direction parallel to an optic axis of said projection optical system of said sensitized substrate in a predetermined measure point in a measuring region which consists of a field of this side at the time of said sensitized substrate being scanned to a conjugate exposure region and this exposure region about an illuminated field and said projection optical system of said specified shape,

A calculating means which asks for difference of average height of an exposure surface of said sensitized substrate, and height of the image surface of said projection optical system based on the maximum and the minimum of two or more height measurement results obtained by said height measurement means when said sensitized substrate is scanned,

A surface position setting device having a height setting-out stage which sets up height of said sensitized substrate based on difference of said height which was provided in said substrate side stage and found by said calculating means.

[Claim 6 In a scanning type exposure device which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A detection means to detect position information on said 2nd object about an optical axis direction of said projection system in two or more measure points during movement of said 2nd object,

It has a setting-out means to set up inclination of said 2nd object during movement of said 2nd object based on a detection result of said detection means,

A scanning type exposure device, wherein this setting-out means changes speed of response when setting up inclination of speed of response when setting up inclination of the move direction of said 2nd object, the move direction of said 2nd object, and a crossing direction.

[Claim 7 In a scanning type exposure device which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A detection means to detect position information on said 2nd object about an optical axis direction of said projection system in two or more measure points during movement of said 2nd object,

An adjustment device which adjusts physical relationship of the image surface of said projection system, and said 2nd object during movement of said 2nd object based on the maximum of the position information detected in two or more detecting points of said detection means, and the minimum,

A scanning type exposure device characterized by preparation .

[Claim 8 The scanning type exposure device according to claim 7, wherein said adjustment device performs weighting to said maximum and said minimum and coincides a field of a request on said 2nd object with the image surface of said projection system substantially.

[Claim 9 The scanning type exposure device according to claim 7 or 8, wherein said adjustment device adjusts inclination relation between the image surface of said projection system, and said 2nd object about the move direction of said 2nd object, and a crossing direction.

[Claim 10 In a scanning type exposure device which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A detection means to detect position information on said 2nd object about an optical axis direction of said projection system in two or more detecting points during movement of said 2nd object,

An alignment means to carry out weighting to position information detected in two or more detecting points of said detection means, and to perform alignment of a field of a request on said 2nd object, and the image surface of said projection system during movement of said 2nd object,

A scanning type exposure device characterized by preparation .

[Claim 11 The scanning type exposure device according to claim 10, wherein said alignment means adjusts inclination relation between a request side on said 2nd object, and the image surface of said projection system about the move direction of said 2nd object, and a crossing direction.

[Claim 12 The scanning type exposure device according to claim 10 or 11 having an independently movable respectively supporting point, adjusting movement magnitude of this supporting point, respectively, and performing alignment of the image surface of said projection system, and a field of a request on said 2nd object while said alignment means supports said 2nd object.

[Claim 13 In a scanning type exposure device which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A detection means to detect position information on said 2nd object about an optical axis direction of said projection system in two or more detecting points during movement of said 2nd object,

It has a setting-out means to perform field setting out of said 2nd object to the image surface of said projection system during movement of said 2nd object based on a detection result of said detection means,

A scanning type exposure device changing speed of response when performing field setting out of said 2nd object according to movement speed of said 2nd object.

[Claim 14 The scanning type exposure device according to claim 13, wherein said speed of response is managed with a filter.

[Claim 15 The scanning type exposure device according to claim 13, wherein change of said speed of response includes change of a servo gain of an actuator of said setting-out means.

[Claim 16 The scanning type exposure device according to any one of claims 6 to 15, wherein said detection means has a detecting point in an irradiation area of an exposure beam which passed said projection system.

[Claim 17 The scanning type exposure device according to any one of claims 6 to 15, wherein said detection means has a detecting point which is distant from an irradiation area of an exposure beam which passed said projection system.

[Claim 18 The scanning type exposure device according to any one of claims 6 to 17, wherein said two or more detecting points are left and set up in the move direction of said 2nd object, and the crossing direction.

[Claim 19 The scanning type exposure device according to claim 18, wherein said two or more detecting points are arranged in two dimensions.

[Claim 20 In a scanning type exposure device which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A detection means to detect concavo-convex information on an exposure surface of said 2nd object,

In order to perform alignment of an exposure surface of said 2nd object, and the image surface of said projection system during scanning exposure of an exposure surface of said 2nd object, it has a setting-out means to perform field setting out of said exposure surface based on

concavo-convex information detected by said detection means,
A scanning type exposure device, wherein this setting-out means controls field setting out which worsens alignment accuracy of said image surface and said exposure surface.
[Claim 21 The scanning type exposure device according to claim 20 detecting concavo-convex information on an exposure surface of said 2nd object by said detection means in advance of scanning exposure of said 2nd object moving said 2nd object in order to control said field setting out.
[Claim 22 The scanning type exposure device according to claim 20 or 21 when said detection means measures [position information on an exposure surface of said 2nd object about an optical axis direction of said projection system in two or more measure points during movement of said 2nd object, wherein it detects said concavo-convex information.
[Claim 23 The scanning type exposure device according to any one of claims 20 to 22, wherein said setting-out means has a restraint means for controlling said field setting out.
[Claim 24 The scanning type exposure device according to claim 23, wherein said restraint means controls said field setting out by carrying out filtering processing of the information detected by said detection means.
[Claim 25 The scanning type exposure device according to any one of claims 20 to 23 controlling said field setting out by said setting-out means having an actuator for moving a supporting point of said 2nd object to an optical axis direction of said projection system, and adjusting a servo gain of this actuator.
[Claim 26 The scanning type exposure device according to claim 25, wherein said servo gain is variable according to movement speed of said 2nd object.
[Claim 27 The scanning type exposure device according to any one of claims 20 to 26, wherein said setting-out means controls setting out of inclination to an exposure surface of said 2nd object.
[Claim 28 A device manufacturing method using the scanning type exposure device according to any one of claims 6 to 27.
[Claim 29 In a scanning exposure method which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,
A scanning exposure method changing speed of response when setting up inclination of said 2nd object during movement of said 2nd object and setting up inclination of speed of response when setting up inclination of the move direction of said 2nd object, the move direction of said 2nd object, and a crossing direction.
[Claim 30 In a scanning exposure method which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A scanning exposure method changing speed of response when setting up inclination of the move direction of said 2nd object according to movement speed of said 2nd object when setting up inclination of said 2nd object during movement of said 2nd object.

[Claim 31 In a scanning exposure method which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

While detecting position information on said 2nd object about an optical axis direction of said projection system in two or more measure points during movement of said 2nd object, A scanning exposure method characterized by adjusting physical relationship of the image surface of said projection system, and said 2nd object based on the maximum of the position information detected in a detecting point of this plurality, and the minimum.

[Claim 32 In a scanning exposure method which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

A scanning exposure method which carries out weighting to position information which detects position information on said 2nd object about an optical axis direction of said projection system in two or more detecting points, and is detected in a detecting point of this plurality during movement of said 2nd object, and is characterized by a thing of a field of a request on said 2nd object, and the image surface of said projection system to do for alignment.

[Claim 33 The scanning exposure method according to claim 31 or 32, wherein said two or more detecting points contain a detecting point in an irradiation area of an exposure beam which passed said projection system.

[Claim 34 The scanning exposure method according to any one of claims 31 to 33, wherein said two or more detecting points contain a detecting point which is distant from an irradiation area of an exposure beam which passed said projection system.

[Claim 35 The scanning exposure method according to claim 33 or 34, wherein said two or more detecting points contain two or more detecting points left in the move direction of said 2nd object, and the crossing direction.

[Claim 36 In a scanning exposure scanning exposure method which carries out scanning exposure of said 2nd object by moving the 2nd object to an exposure beam which passed a projection system synchronizing with moving the 1st object to an exposure beam,

When carrying out scanning exposure of said exposure surface, performing field setting out of said exposure surface based on concavo-convex information on said exposure surface in order to perform alignment of an exposure surface of said 2nd object, and the image surface of said projection system, A scanning exposure method controlling field setting out which worsens alignment accuracy of said image surface and said exposure surface.

[Claim 37 The scanning exposure method according to claim 36 detecting concavo-convex information on an exposure surface of said 2nd object in advance of scanning exposure of said 2nd object moving said 2nd object in order to control said field setting out.

[Claim 38 The scanning exposure method according to claim 37 when position information on an exposure surface of said 2nd object about an optical axis direction of said projection system detects said concavo-convex information in two or more measure points, moving said 2nd object, wherein it searches for.

[Claim 39 The scanning exposure method according to any one of claims 36 to 38, wherein control of said field setting out includes control of inclination setting out of an exposure surface of said 2nd object.

[Claim 40 A device manufacturing method using the scanning exposure method according to any one of claims 29 to 39.

[The amendment 3]

[Document to be Amended Specification

[Item(s) to be Amended 0001

[Method of Amendment]Change

[Proposed Amendment

[0001]

[Industrial Application This invention is used for the projection aligner of the slit scan exposure system provided with the autofocusing mechanism or the auto leveling mechanism, for example, and relates to a suitable scanning exposure method. This invention relates to the device manufacturing method which uses the surface position setting device and scanning type exposure device which can be used when enforcing such a scanning exposure method, and its scanning exposure method.

[Amendment 4]

[Document to be Amended Specification

[Item(s) to be Amended 0014

[Method of Amendment]Change

[Proposed Amendment

[0014]In view of this point, an object of this invention is to provide the scanning exposure method which can be used in order to double the exposure surface of a sensitized substrate with high precision to the image surface of a projection optical system in the projection aligner of a slit scan exposure system. An object of this invention is also to provide the device manufacturing method which can manufacture a device with high precision using the surface position setting device and scanning type exposure device which can be used when enforcing the scanning exposure method, and its scanning exposure method.

[Amendment 5]

[Document to be Amended Specification

[Item(s) to be Amended 0018
[Method of Amendment]Change
[Proposed Amendment

[0018]As for the multipoint measurement means, it is desirable to change the position of the measure point of these plurality to one shot region of a sensitized substrate (5) one by one in the process in which the pattern of a mask (12) is exposed one by one. The 2nd surface position setting device by this invention, The mask side stage (10) which scans the mask (12) in which the pattern for exposure was formed to the illumination-light study system which illuminates the illuminated field of specified shape, and its illuminated field by exposing light, The projection optical system (8) which projects the pattern of the mask (12) in the illuminated field on a sensitized substrate (5), It is provided in the exposure device which has the substrate side stage (2) which scans a sensitized substrate (5) synchronizing with a mask (12), It is a surface position setting device for doubling the height of the exposure surface of a sensitized substrate (5) with the image surface of a projection optical system (8), In the predetermined measure point in the measuring region which consists of a field of this side at the time of a sensitized substrate (5) being scanned to a conjugate exposure region (24) and this exposure region about the illuminated field and projection optical system (8) of that specified shape, A height measurement means (62A, 69A) to measure the height of a direction parallel to the optic axis of the projection optical system (8) of a sensitized substrate (5), It is provided in the calculating means (71A) which asks for the difference of the average height of the exposure surface of a sensitized substrate (5), and the height of the image surface of a projection optical system (8) based on the maximum and the minimum of two or more height measurement results obtained by the height measurement means when a sensitized substrate (5) is scanned, and the substrate side stage (2), Based on the difference of the height found by the calculating means (71A), it has a height setting-out stage (4) which sets up the height of a sensitized substrate (5). Next, the 1st scanning type exposure device by this invention, Synchronizing with moving the 1st object to an exposure beam, by moving the 2nd object to the exposure beam which passed the projection system, A detection means to detect the position information on the 2nd object about the optical axis direction of the projection system in two or more measure points during movement of the 2nd object in the scanning type exposure device which carries out scanning exposure of the 2nd object, Have a setting-out means to set up inclination of the 2nd object during movement of the 2nd object based on the detection result of the detection means, and this setting-out means, Speed of response when setting up inclination of the speed of response and the move direction of the 2nd object of [when setting up inclination of the move direction of the 2nd object], and the crossing direction is changed. The 2nd scanning type exposure device by this invention, Synchronizing with moving the 1st object to an exposure beam, by moving the 2nd object to the exposure beam which passed the projection system, A detection means to detect the position information on the 2nd object about the optical axis direction of the projection system in two or more measure points during movement of the 2nd object in the scanning type exposure device which carries out scanning exposure of the 2nd object, It has an adjustment device which adjusts the physical relationship of the image surface and the 2nd object of the projection system during movement of the 2nd object based on the maximum of the position information detected in two or more detecting points of the detection means, and the minimum. The 3rd scanning type exposure device by this invention, Synchronizing with moving the 1st object to an exposure beam, by moving the 2nd object to the exposure beam which passed the projection system, A detection means to detect the position information on the 2nd object about the optical axis direction of the projection system in two or more detecting points during movement of the 2nd object in the scanning type exposure device which carries out scanning exposure of the 2nd object, It has an alignment means to carry out weighting to the position information detected in two or more detecting points of the detection means, and to perform alignment of the field and the image surface of a projection system of the request on the 2nd object during movement of the 2nd object. The 4th scanning type exposure device by this invention, Synchronizing with moving the 1st object to an exposure beam, by moving the 2nd object to the exposure beam which passed the projection system, A detection means to detect the position information on the 2nd object about the optical axis direction of the projection system in two or more detecting points during movement of the 2nd object in the scanning type exposure device which carries out scanning exposure of the 2nd object, During movement of the 2nd object, it has a setting-out means to perform field setting out of the 2nd object to the image surface of the projection system based on the detection result of the detection means, and speed of response when performing field setting out of the 2nd object is changed according to the movement speed of the 2nd object.The 5th scanning type exposure device by this invention, Synchronizing with moving the 1st object to an exposure beam, by moving the 2nd object to the exposure beam which passed the projection system, A detection means to detect the concavo-convex information on the exposure surface of the 2nd object in the scanning type exposure device which carries out scanning exposure of the 2nd object, It has a setting-out means to perform field setting out of the exposure surface based on the concavo-convex information detected by the detection means in order to perform alignment of the exposure surface and the image surface of a projection system of the 2nd object during the scanning exposure of the exposure surface of the 2nd object, This setting-out means controls field setting out which worsens the alignment accuracy of the image surface and its exposure surface. The 1st scanning exposure method by this invention next, by moving the 2nd object to the exposure beam which passed the projection system synchronizing with moving the 1st object to an exposure beam, In the scanning exposure method which carries out scanning exposure of the 2nd object, when setting up inclination of the 2nd object during movement of the 2nd object, speed of response when setting up inclination of the speed of response and the move direction of the 2nd object of when setting up inclination of the move direction of the 2nd object], and the crossing direction is changed.The 2nd scanning exposure method by this invention by moving the 2nd object to the exposure beam which passed the projection system synchronizing with moving the 1st object to an exposure beam, In the scanning exposure method which carries out scanning exposure of the 2nd object, when setting up inclination of the 2nd object during movement of the 2nd object, speed of response when setting up inclination of the move direction of the 2nd object is changed according to the movement speed of the 2nd object. The 3rd scanning exposure method by this invention by moving the 2nd object to the exposure beam which passed the projection system synchronizing with moving the 1st object to an exposure beam, In the scanning exposure method which carries out scanning exposure of the 2nd object, while detecting the position information on the 2nd object about the optical axis direction of the projection system in two or more measure points during movement of the 2nd object, Based on the maximum of the position information detected in the detecting point of this plurality, and the minimum, the physical relationship of the image surface and the 2nd object of the projection system is adjusted. The 4th scanning exposure method by this invention by moving the 2nd object to the exposure beam which passed the projection system synchronizing with moving the 1st object to an exposure beam, In the scanning exposure method which carries out scanning exposure, the 2nd object during movement of the 2nd object, Weighting is carried out to the position information which detects the position information on the 2nd object about the optical axis direction of the projection system in two or more detecting points, and is detected in the detecting point of this plurality, and it is a thing of the field and the image surface of a projection system of the request on the 2nd object which carries out alignment. The 5th scanning exposure method by this invention by moving the 2nd object to the exposure beam which passed the projection system synchronizing with moving the 1st object to an exposure beam, When carrying out scanning exposure of the exposure surface, performing field setting out of the exposure surface based on the concavo-convex information on the exposure surface in the scanning exposure scanning exposure method which carries out scanning exposure of the 2nd object in order to perform alignment of the exposure surface and the image surface of a projection system of the 2nd object, Field setting out which worsens the alignment accuracy of the image surface and its exposure surface is controlled. Next, the scanning type exposure device of above-mentioned this invention is used for the 1st device manufacturing method by this invention. The scanning exposure method of above-mentioned this invention is used for the 2nd device manufacturing method by this invention.

[Amendment 6]

[Document to be Amended Specification
[Item(s) to be Amended 0019
[Method of Amendment]Change
[Proposed Amendment
[0019]

[Function]When scanning the sensitized substrate (5) as the mask (12) and the 2nd object as the 1st object synchronously in this this invention and exposing the pattern image of a mask (12) on a sensitized substrate (5), For example, the height of a sensitized substrate (5) is measured using the multipoint measurement means in two or more measure points containing the measure point before the direction of the scan. And it asks for the angle of inclination of a sensitized substrate (5) by acquiring multiple-times height information in accordance with the direction of a scan, respectively in the measure point of these plurality. Then, when exposing the pattern image of a mask (12) to the field to which the angle of inclination was called for such, the angle of inclination of the field is set up based on the angle of inclination for which it asked beforehand. Thereby, the exposure surface of a sensitized substrate (5) is set up in parallel with the image surface of a projection optical system (8) also with a slit scan exposure system.

[Amendment 7]
[Document to be Amended Specification
[Item(s) to be Amended 0027
[Method of Amendment]Change
[Proposed Amendment

[0027]In this invention, in order to remove these errors, the response of the scanning direction of a leveling mechanism and the response of the non-scanning direction are changed. It is premised on the focal position detection system of an oblique incidence type multipoint as a multipoint measurement means for auto leveling mechanisms in this invention. It aims at making the maximum of the gap with each point of the exposure surface in the predetermined field, and the image surface of a projection optical system into the minimum regardless of the average field of the exposure surface of the sensitized substrate in the predetermined field in the exposure field of a projection optical system. Thus, in the predetermined field in the exposure field of a projection optical system, an exposure field in case the maximum of the gap with almost all the points of the exposure surface of a sensitized substrate and the image surface of a projection optical system is the minimum is called the good field (Good Field).

[Amendment 8]
[Document to be Amended Specification
[Item(s) to be Amended 0035
[Method of Amendment]Change

[Proposed Amendment

[0035]Next, the autofocus control in this invention is considered. If the concept of the above-mentioned good field (Good Field) is taken in, as shown in drawing 16, Equalizing processing of the focusing position of each measure point in the center section 24a of the exposure field 24 is performed, and if the field shown by the average value of the focusing position is doubled with the image surface of a projection optical system, accuracy may get worse. That is, drawing 18 (a) shows the field 34A corresponding to the average value of the focusing position of each measure point of the exposure surface 5a with the crevice of depth H of a sensitized substrate, and the difference deltaZ3 of the focusing direction of the field 34A and crevice is larger than H 2.

[Amendment 9]

[Document to be Amended Specification

[Item(s) to be Amended 0097

[Method of Amendment]Change

[Proposed Amendment

[0097]

[Effect of the Invention According to the 1st surface position setting device of this invention, the 1st scanning type exposure device, the 1st scanning exposure method, etc. In the projection aligner of a slit scan exposure system, the error by unevenness of the surface of a sensitized substrate, the measurement accuracy of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the exposure surface of a sensitized substrate can be doubled in parallel with high precision to the image surface of a projection optical system.

[Amendment 10]

[Document to be Amended Specification

[Item(s) to be Amended 0099

[Method of Amendment]Change

[Proposed Amendment

[0099]When a multipoint measurement means changes the position of two or more measure points to one shot region of a sensitized substrate one by one in the process in which the pattern of a mask is exposed one by one, For example, by using together division destination reading and full prediction, both leveling accuracy and a throughput are improvable. According to the 2nd surface position setting device of this invention, the 2nd scanning type exposure device, the 3rd scanning exposure method, etc. In the projection aligner of a slit scan exposure system, the error by unevenness of the surface of a sensitized substrate, the measurement accuracy of a multipoint measurement means, air fluctuation, etc. is amended, and there is an advantage with which the focusing position of the exposure surface of a sensitized substrate

can be correctly doubled to the image surface of a projection optical system.
[Amendment 11]
[Document to be Amended Specification
[Item(s) to be Amended Drawing 1
[Method of Amendment]Change
[Proposed Amendment
[Drawing 1 It is a lineblock diagram showing the projection aligner of one example of this invention.

[Translation done.]

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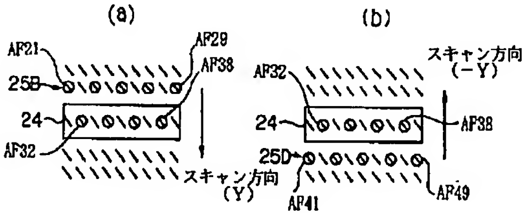
(54)【発明の名称】　面位置設定装置

(57)【要約】

【目的】　スリットスキャン露光方式の投影露光装置において、感光基板の露光面を投影光学系の像面に対して高精度に合わせ込む。

【構成】　スリット状の露光フィールド24に対してウエハをY方向に走査して露光を行う場合には、走査方向に対して手前の第2列25B内のサンプル点AF21〜AF29及び露光フィールド24内のサンプル点AF32〜AF38で得られたフォーカス位置の情報からウエハのレベリング及びフォーカシングの制御を行う。また、ウエハを－Y方向に走査して露光を行う場合には、走査方向に対して手前の第4列25D内のサンプル点AF41〜AF49及び露光フィールド24内のサンプル点AF32〜AF38で得られたフォーカス位置の情報からウエハのレベリング及びフォーカシングの制御を行う。



【特許請求の範囲】

【請求項1】　露光光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して露光用のパターンが形成されたマスクを走査するマスク側ステージと、前記照明領域内の前記マスクのパターンを感光基板上に投影する投影光学系と、前記マスクと同期して前記感光基板を走査する基板側ステージとを有する露光装置に設けられ、前記感光基板の露光面を前記投影光学系の像面に平行に合わせ込むための面位置設定装置であって、

前記感光基板が走査される方向に交差する方向の複数の点を含む複数の計測点において前記感光基板の前記投影光学系の光軸に平行な方向の高さをそれぞれ計測する多点計測手段と、

該多点計測手段の計測結果より前記感光基板の露光面と前記投影光学系の像面との間の傾斜角の差分を求める演算手段と、

前記基板側ステージに設けられ、前記演算手段により求められた前記傾斜角の差分に基づいて、前記感光基板の前記走査の方向の傾斜角及び前記走査の方向に直交する方向の傾斜角を設定する傾斜設定ステージとを有し、

該傾斜設定ステージが前記感光基板の前記走査の方向の傾斜角を設定するときの応答速度と、前記走査の方向に直交する方向の傾斜角を設定するときの応答速度とを異ならしめたことを特徴とする面位置設定装置。

【請求項2】　前記多点計測手段は、前記基板側ステージを介して前記感光基板が走査されているときに、前記基板側ステージの位置基準で前記複数の計測点における前記感光基板の高さをサンプリングすることを特徴とする請求項1記載の面位置設定装置。

【請求項3】　前記多点計測手段は、前記所定形状の照明領域と前記投影光学系に関して共役な露光領域内の複数の点及び前記共役な露光領域内に対して前記感光基板が走査される際の手前の領域内の複数の点よりなる複数の計測点において、前記感光基板の高さをそれぞれ計測することを特徴とする請求項1又は2記載の面位置設定装置。

【請求項4】　前記多点計測手段は、前記感光基板の1つのショット領域へ順次前記マスクのパターンを露光する過程において、順次前記複数の計測点の位置を変化させることを特徴とする請求項1記載の面位置設定装置。

【請求項5】　露光光で所定形状の照明領域を照明する照明光学系と、前記照明領域に対して露光用のパターンが形成されたマスクを走査するマスク側ステージと、前記照明領域内の前記マスクのパターンを感光基板上に投影する投影光学系と、前記マスクと同期して前記感光基板を走査する基板側ステージとを有する露光装置に設けられ、前記感光基板の露光面の高さを前記投影光学系の像面に合わせ込むための面位置設定装置であって、

前記所定形状の照明領域と前記投影光学系に関して共役な露光領域及び該露光領域に対して前記感光基板が走査される際の手前の領域よりなる計測領域内の所定の計測点において、前記感光基板の前記投影光学系の光軸に平行な方向の高さを計測する高さ計測手段と、

前記感光基板を走査した際に前記高さ計測手段により得られる複数の高さ計測結果の内の、最大値及び最小値に基づいて前記感光基板の露光面の平均的な高さと前記投影光学系の像面の高さとの差分を求める演算手段と、

前記基板側ステージに設けられ、前記演算手段により求められた前記高さの差分に基づいて、前記感光基板の高さを設定する高さ設定ステージとを有することを特徴とする面位置設定装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、例えばスリットスキャン露光方式の投影露光装置のオートフォーカス機構又はオートレベリング機構に適用して好適な面位置設定装置に関する。

【0002】

【従来の技術】半導体素子、液晶表示素子又は薄膜磁気ヘッド等をフォトリソグラフィ工程で製造する際に、フォトマスク又はレチクル（以下、「レチクル」と総称する）のパターンを感光材が塗布された基板（ウエハ、ガラスプレート等）上に転写する投影露光装置が使用されている。従来の投影露光装置としては、ウエハの各ショット領域を順次投影光学系の露光フィールド内に移動させて、各ショット領域に順次レチクルのパターン像を露光するというステップ・アンド・リピート方式の縮小投影型露光装置（ステッパー）が多く使用されていた。

【0003】図20は従来のステッパーの要部を示し、この図20において、図示省略された照明光学系からの露光光ELのもとで、レチクル51上のパターンの像が投影光学系52を介してフォトレジストが塗布されたウエハ53上の各ショット領域に投影露光される。ウエハ53は、Zレベリングステージ54上に保持され、Zレベリングステージ54はウエハ側XYステージ55の上に載置されている。ウエハ側XYステージ55は、投影光学系52の光軸AX1に垂直な平面（XY平面）内でウエハ53の位置決めを行い、Zレベリングステージ54は、ウエハ53の露光面のフォーカス位置（光軸AX1に平行な方向の位置）及びその露光面の傾斜角を指定された状態に設定する。

【0004】また、Zレベリングステージ54上に、移動鏡56が固定されている。外部のレーザ干渉計57からのレーザビームがその移動鏡56で反射され、ウエハ側XYステージ55のX座標及びY座標がレーザ干渉計57により常時検出され、これらX座標及びY座標が主制御系58に供給されている。主制御系58は、駆動装置59を介してウエハ側XYステージ55及びZレベリングステージ54の動作を制御することにより、ステップ・アンド・リピート方式でウエハ53上の各ショット

領域に順次レチクル５１のパターン像を露光する。

【０００５】この際、レチクル５１上のパターン形成面（レチクル面）とウエハ５３の露光面とは投影光学系５２に関して共役になっている必要があるが、投影倍率が高く、焦点深度が大きい為にレチクル面はあまり変動しない。そこで、従来は一般に、斜め入射型の多点のフォーカス位置検出系によってウエハ５３の露光面が投影光学系５２の像面に焦点深度の範囲内で合致しているかどうか（合焦しているかどうか）のみを検出し、ウエハ５３の露光面のフォーカス位置及び傾斜角の制御を行っていた。

【０００６】従来の多点のフォーカス位置検出系において、露光光ＥＬとは異なりウエハ５３上のフォトレジストを感光させない照明光が、図示省略された照明光源から光ファイバ束６０を介して導かれている。光ファイバ束６０から射出された照明光は、集光レンズ６１を経てパターン形成板６２を照明する。パターン形成板６２を透過した照明光は、レンズ６３、ミラー６４及び照射対物レンズ６５を経てウエハ５３の露光面に投影され、ウエハ５３の露光面にはパターン形成板６２上のパターンの像が光軸ＡＸ１に対して斜めに投影結像される。ウエハ５３で反射された照明光は、集光対物レンズ６６、回転方向振動板６７及び結像レンズ６８を経て受光器６９に受光面に再投影され、受光器６９の受光面には、パターン形成板６２上のパターンの像が再結像される。この場合、主制御系５８は加振装置７０を介して回転方向振動板６７に後述のような振動を与え、受光器６９の多数の受光素子からの検出信号が信号処理装置７１に供給され、信号処理装置７１は、各検出信号を加振装置７０の駆動信号で同期検波して得た多数のフォーカス信号を主制御系５８に供給する。

【０００７】図２１（ｂ）は、パターン形成板６２上に形成された開口パターンを示し、この図２１（ｂ）に示すように、パターン形成板６２上には十字状に９個のスリット状の開口パターン７２－１～７２－９が設けられている。それらの開口パターン７２－１～７２－９はウエハ５３の露光面に対してＸ軸及びＹ軸に対して４５°で交差する方向から照射されるため、ウエハ５３の露光面上の投影光学系５２の露光フィールド内での、それら開口パターン７２－１～７２－９の各投影像ＡＦ１～ＡＦ９は図２１（ａ）に示すような配置になる。図２１（ａ）において、投影光学系５２の円形の照明視野に内接して最大露光フィールド７４が形成され、最大露光フィールド７４内の中央部及び２個の対角線上の計測点ＡＦ１～ＡＦ９にそれぞれスリット状の開口パターンの投影像が投影されている。

【０００８】図２１（ｃ）は、受光器６９の受光面の様子を示し、この図２１（ｃ）に示すように、受光器６９の受光面には十字型に９個の受光素子７５－１～７５－９が配置され、各受光素子７５－１～７５－９の上にはスリット状の開口を有する遮光板（図示省略）が配置されている。そして、図２１（ａ）の各計測点ＡＦ１～ＡＦ９上の像がそれぞれ受光器６９の各受光素子７５－１～７５－９の上に再結像されている。この場合、図２０のウエハ５３の露光面（ウエハ面）で反射された照明光は、集光対物レンズ６６の瞳位置に存在すると共に図２０の紙面にほぼ垂直な軸の回りに振動（回転振動）する回転方向振動板６７に反射されるため、図２１（ｃ）に示すように、受光器６９上では各受光素子７５－１～７５－９上に再結像される投影像の位置がスリット状の開口の幅方向であるＲＤ方向に振動する。

【０００９】また、図２１（ａ）の各計測点ＡＦ１～ＡＦ９上のスリット状の開口の像は、投影光学系５２の光軸に対して斜めに投影されているため、ウエハ５３の露光面のフォーカス位置が変化すると、それら投影像の受光器６９上での再結像位置はＲＤ方向に変化する。従って、信号処理装置７１内で、各受光素子７５－１～７５－９の検出信号をそれぞれ回転方向振動板６７の加振信号で同期検波することで、計測点ＡＦ１～ＡＦ９のフォーカス位置にそれぞれ対応する９個のフォーカス信号が得られる。そして、９個のフォーカス位置から、露光フィールド７４の平均的な面の傾斜角及びその平均的な面のフォーカス位置が求められて主制御系５８に供給され、主制御系５８は、駆動装置５９及びＺレベリングステージ５４を介してウエハ５３の当該ショット領域のフォーカス位置及び傾斜角（レベリング角）を所定の値に設定する。このようにして、ステッパーにおいては、ウエハ５３の各ショット領域においてフォーカス位置及び傾斜角が投影光学系５２の像面に合わせ込まれた状態で、それぞれレチクル５１のパターン像が露光されていた。

【００１０】

【発明が解決しようとする課題】近年、半導体素子等においてはパターンが微細化しているため、投影光学系の解像力を高めることが求められている。解像力を高めるための手法には、露光光の波長の短波長化、又は投影光学系の開口数の増大等の手法があるが、何れの手法を用いる場合でも、従来例と同じ程度の露光フィールドを確保しようとすると、露光フィールドの全面で結像性能（ディストーション、像面湾曲等）を所定の精度に維持することが困難になってきている。そこで現在見直されているのが、所謂スリットスキャン露光方式の投影露光装置である。

【００１１】このスリットスキャン露光方式の投影露光装置では、矩形状又は円弧状等の照明領域（以下、「スリット状の照明領域」という）に対してレチクル及びウエハを相対的に同期して走査しながら、そのレチクルのパターンがウエハ上に露光される。従って、前記スリット状の照明領域と共役な領域内で像が平均化され、ディストーション精度が向上するという利点があった。

【0012】また、従来のレチクルの大きさの主流は6インチサイズであり、投影光学系の投影倍率の主流は1／5倍であったが、半導体素子等の回路パターンの大面積化により、倍率1／5倍のもとでのレチクルの大きさは6インチサイズでは間に合わなくなっている。そのため、投影光学系の投影倍率を例えば1／4倍に変更した投影露光装置を設計する必要がある。そして、このような被転写パターンの大面積化に対して投影光学系の露光フィールド径を小さくする事ができるスリットスキャン露光方式がコスト面に於いても有利である。

【0013】斯かるスリットスキャン露光方式の投影露光装置において、従来のステッパーで用いられていた多点型のフォーカス位置検出系をそのまま適用して、ウエハ上の露光面のフォーカス位置及び傾斜角を計測したとしても、ウエハが所定の方向に走査されているため、実際の露光面を投影光学系の像面に合わせ込むことが困難であるという不都合があった。即ち、従来はスリットスキャン露光方式の投影露光装置において、ウエハのフォーカス位置及び傾斜角を投影光学系の像面に合わせ込むための手法が確率されていなかった。

【0014】本発明は斯かる点に鑑み、スリットスキャン露光方式の投影露光装置において、感光基板の露光面を投影光学系の像面に対して高精度に合わせ込むために使用できるような面位置設定装置を提供することを目的とする。

【0015】

【課題を解決するための手段】本発明の第1の面位置設定装置は、露光光で所定形状の照明領域を照明する照明光学系と、その照明領域に対して露光用のパターンが形成されたマスク（12）を走査するマスク側ステージ（10）と、その照明領域内のマスク（12）のパターンを感光基板（5）上に投影する投影光学系（8）と、マスク（12）と同期して感光基板（5）を走査する基板側ステージ（2）とを有する露光装置に設けられ、感光基板（5）の露光面を投影光学系（8）の像面に平行に合わせ込むための面位置設定装置であって、感光基板（5）が走査される方向に交差する方向の複数の点を含む複数の計測点（AF11～AF59）において感光基板（5）の投影光学系（8）の光軸に平行な方向の高さをそれぞれ計測する多点計測手段（62A，69A）と、この多点計測手段の計測結果より感光基板（5）の露光面と投影光学系（8）の像面との間の傾斜角の差分を求める演算手段（71A）とを有する。

【0016】更に本発明は、基板側ステージ（2）に設けられ、演算手段（71A）により求められたその傾斜角の差分に基づいて、感光基板（5）のその走査の方向（Y方向）の傾斜角及びその走査の方向に直交する方向（X方向）の傾斜角を設定する傾斜設定ステージ（4）を有し、例えば図5に示すように、傾斜設定ステージ（4）が感光基板（5）のその走査の方向（Y方向）の傾斜角θ_Yを設定するときの応答速度と、その走査の方向に直交する方向（X方向）の傾斜角θ_Xを設定するときの応答速度とを異ならしめたものである。

【0017】この場合、その多点計測手段は、基板側ステージ（2）を介して感光基板（5）が走査されているときに、基板側ステージ（2）の位置基準でそれら複数の計測点における感光基板（5）の高さをサンプリングしても良い。また、その多点計測手段は、その所定形状の照明領域と投影光学系（8）に関して共役な露光領域（24）内の複数の点及びその共役な露光領域内に対して感光基板（5）が走査される際の手前の領域内の複数の点よりなる複数の計測点において、感光基板（5）の高さをそれぞれ計測するものであっても良い。

【0018】また、その多点計測手段は、感光基板（5）の1つのショット領域へ順次マスク（12）のパターンを露光する過程において、順次それら複数の計測点の位置を変化させることが望ましい。また、本発明による第2の面位置設定装置は、露光光で所定形状の照明領域を照明する照明光学系と、その照明領域に対して露光用のパターンが形成されたマスク（12）を走査するマスク側ステージ（10）と、その照明領域内のマスク（12）のパターンを感光基板（5）上に投影する投影光学系（8）と、マスク（12）と同期して感光基板（5）を走査する基板側ステージ（2）とを有する露光装置に設けられ、感光基板（5）の露光面の高さを投影光学系（8）の像面に合わせ込むための面位置設定装置であって、その所定形状の照明領域と投影光学系（8）に関して共役な露光領域（24）及びこの露光領域に対して感光基板（5）が走査される際の手前の領域よりなる計測領域内の所定の計測点において、感光基板（5）の投影光学系（8）の光軸に平行な方向の高さを計測する高さ計測手段（62A，69A）と、感光基板（5）を走査した際にその高さ計測手段により得られる複数の高さ計測結果の内の、最大値及び最小値に基づいて感光基板（5）の露光面の平均的な高さと投影光学系（8）の像面の高さとの差分を求める演算手段（71A）と、基板側ステージ（2）に設けられ、演算手段（71A）により求められたその高さの差分に基づいて、感光基板（5）の高さを設定する高さ設定ステージ（4）とを有するものである。

【0019】

【作用】斯かる本発明の第1の面位置設定装置においては、マスク（12）及び感光基板（5）を同期して走査して感光基板（5）上にマスク（12）のパターン像を露光する際に、例えばその走査の方向の手前の計測点を含む複数の計測点でその多点計測手段を用いて感光基板（5）の高さを計測する。そして、それら複数の計測点でそれぞれ走査の方向に沿って複数回高さ情報を得ることにより、感光基板（5）の傾斜角を求める。その後、そのように傾斜角が求められた領域にマスク（12）の

パターン像を露光する際に、予め求めた傾斜角に基づいてその領域の傾斜角を設定する。これにより、スリットスキャン露光方式でも感光基板（5）の露光面が投影光学系（8）の像面に平行に設定される。

【0020】また、本発明ではそのようなレベリングを行う際に、スキャン方向のレベリングの応答速度と、非スキャン方向レベリングの応答速度とが異なっている。これによる作用効果につき説明するため、スリットスキャン露光時のフォーカシング及びレベリングの誤差要因について説明する。スリットスキャン露光方式の露光装置では、以下の誤差が考えられる。

①フォーカスオフセット誤差及び振動誤差

フォーカスオフセット誤差とは、露光面の平均的な面と投影光学系の像面とのフォーカス位置の差であり、振動誤差とは走査露光する際の基板側ステージのフォーカス方向の振動等に起因する誤差である。これについて、オートフォーカス制御だけを行うものとして、ステッパーのように一括露光する場合と、スリットスキャン露光方式で露光する場合とに分けてより詳細に説明する。

【0021】図14（a）は一括露光する場合、図14（b）はスリットスキャン露光方式で露光する場合を示す。図14（a）においては、感光基板の露光面5aの平均的な面34が投影光学系の像面に合致しているが、位置Ya，Yb及びYcのフォーカス位置はそれぞれ一定の平均的な面34に対して、－ΔZ1，0及びΔZ2だけ異なっている。従って、位置Ya及びYbにおけるフォーカスオフセット誤差はそれぞれ－ΔZ1及びΔZ2である。

【0022】一方、図14（b）の場合には、スキャン方向に対して露光面5a上の一連の部分的な平均面35A，35B，35C，‥‥が順次投影光学系の像面に合わせ込まれる。従って、各位置Ya，Yb及びYcでのフォーカスオフセット誤差はそれぞれ平均化効果で0となる。しかし、位置Yb上の像を形成するのに、平均面35Bから平均面35Dまでの高さΔZBの間をフォーカス位置が移動するので、位置Yb上の像は、ΔZBだけフォーカス方向にばらつきを持った像になってしまう。同様に、位置Ya及びYc上の像はそれぞれフォーカス方向にΔZA及びΔZBだけばらつきを持った像になる。

【0023】即ち、スリットスキャン露光方式においては、フォーカスオフセット誤差はある一定周波数以下の感光基板面の凹凸に対しほぼ0になるが、基板側ステージのローリング、ピッチング、フォーカス方向（Z軸方向）の振動、低周波空気揺らぎ誤差にオートフォーカス機構及びオートレベリング機構が追従してしまうことによる誤差成分、露光光（KrFエキシマレーザ光等）の短期の波長変動等が、新たな誤差（振動誤差）を生ずる。

【0024】②フォーカス追従誤差、空気揺らぎ誤差、ステージ振動誤差

①で言及した振動誤差の内の代表的な例であり、これらはオートフォーカス機構及びオートレベリング機構の応答周波数に依存するが、更に以下の誤差に分類できる。

(1) 制御系で制御出来ない高周波ステージ振動誤差、露光光（KrFエキシマレーザ光等）の短期の波長変動誤差等、(2) 空気揺らぎ誤差の中で、基板側ステージが追従してしまう低周波空気揺らぎ誤差等、(3) フォーカス位置検出系又は傾斜角検出系の測定結果には含まれるが、基板側ステージが追従しないので、フォーカス誤差にならない測定誤差等。

【0025】③感光基板の露光面の凸凹による誤差

この誤差は、投影光学系による露光フィールドが2次元的な面単位であり、感光基板の露光面でのフォーカス位置の計測を有限個の計測点で且つスリットスキャン露光時に行うことに起因する誤差であり、以下の2つの誤差に分類できる。

(1) 例えば図15（a）及び（b）に示すように、感光基板の露光面5a上の多点でフォーカス位置を計測して位置合わせ対象面（フォーカス面）36A及び36Bを求める場合の計測点の位置に対する演算方法に起因する、そのフォーカス面36Aと理想フォーカス面とのずれの誤差、(2) スキャン速度とオートフォーカス機構及びオートレベリング機構の追従速度との差、フォーカス位置検出系の応答速度等による誤差。

【0026】この場合、フォーカス位置を投影光学系の像面に合わせる場合の応答速度（フォーカス応答）は、図15（c）に示すような時間遅れ誤差と、図15（d）に示すようなサーボゲインとにより決定される。即ち、図15（c）において、曲線37Aは、感光基板の露光面5aの一連の部分領域を順次投影光学系の像面に合わせるためのフォーカス方向用の駆動信号（目標フォーカス位置信号）を示し、曲線38Aは、露光面5aの一連の部分領域のフォーカス方向への移動量を駆動信号に換算して得られた信号（追従フォーカス位置信号）を示す。曲線37Aに対して曲線38Aは一定の時間だけ遅れている。同様に、図15（d）において、曲線37Bは、感光基板の露光面5aの一連の部分領域の目標フォーカス位置信号、曲線38Bは、露光面5aの一連の部分領域の追従フォーカス位置信号であり、曲線37Bに対して曲線38Bの振幅（サーボゲイン）は一定量だけ小さくなっている。

【0027】本発明の第1の面位置設定装置では、これらの誤差を取り除く為に、レベリング機構のスキャン方向の応答性と非スキャン方向の応答性とを変えている。本発明におけるオートレベリング機構用の多点計測手段としては、斜入射型の多点のフォーカス位置検出系を前提とする。また、投影光学系の露光フィールド内の所定の領域での感光基板の露光面の平均的な面を考慮するのではなく、その所定の領域での露光面の各点と投影光学

系の像面とのずれの最大値を最小にすることを目標とする。このように、投影光学系の露光フィールド内の所定の領域において、感光基板の露光面のほぼ全ての点と投影光学系の像面とのずれの最大値が最小である場合の露光フィールドを「良好なフィールド（Good Field）」と呼ぶ。

【００２８】先ず、図１６に示すように、スリット状の照明領域と投影光学系に関して共役なスリット状の露光フィールド２４内にフォーカス位置の多数の計測点（不図示）があると仮定する。図１６において、感光基板上の１つのショット領域SA_{ij}をスリット状の露光フィールド２４に対してY方向に速度V／βで走査するものとして、ショット領域SA_{ij}のスキャン方向の幅をWY、非スキャン方向の幅をWX、露光フィールド２４のスキャン方向の幅をDとする。また、露光フィールド２４内の中心領域２４ａ内の多数の計測点でのフォーカス位置を平均化することにより、露光フィールド２４の中心点での平均的な面のフォーカス位置を求め、露光フィールド２４のスキャン方向の両端の計測領域２４ｂ，２４ｃ内の計測点でのフォーカス位置より最小自乗近似に基づいて平均的な面のスキャン方向の傾斜角θ_Yを求め、露光フィールド２４の非スキャン方向の両端の計測領域２４ｂ，２４ｃ内の計測点でのフォーカス位置より最小自乗近似に基づいて平均的な面の非スキャン方向の傾斜角θ_Xを求めるものとする。また、スキャン方向のレベリングの応答周波数をｆｍ［Ｈｚ］、非スキャン方向のレベリングの応答周波数をｆｎ［Ｈｚ］として、ｆm及びｆｎの値を独立に設定する。

【００２９】そして、感光基板上のショット領域SA_{ij}のスキャン方向の周期的な曲がりの周期を、スキャン方向の幅WY（非スキャン方向も同様の曲がり周期に設定する）との比の値として曲がりパラメータＦで表し、その周期的な曲がりがあるときの露光フィールド２４内の各計測点でのフォーカス誤差を、スキャンした場合のフォーカス誤差の平均値の絶対値と、スキャンした場合のフォーカス誤差の振幅の１／３との和で表す。また、曲がりパラメータＦの周期的な曲がりの振幅を１に規格化し、曲がりパラメータがＦであるときの、それら各計測点でのフォーカス誤差の内の最大値を示す誤差パラメータＳを、曲がりパラメータＦに対する比率として表す。即ち、次式が成立している。

Ｆ＝曲がりの周期／ＷＹ　　（１）
Ｓ＝フォーカス誤差の最大値／Ｆ　　（２）

【００３０】図１７（ａ）は、スキャン方向のレベリングの応答周波数ｆｍ、及び非スキャン方向のレベリングの応答周波数ｆｎが等しく且つ大きい場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ１は非スキャン方向での誤差パラメータＳ、曲線Ｂ１は非スキャン方向の誤差パラメータＳ中の通常のフォーカス誤差の平均値の絶対値、曲線Ａ２はスキャン方向での誤差パラメータＳ、曲線Ｂ２はスキャン方向の誤差パラメータＳ中の通常のフォーカス誤差の平均値を示す。曲線Ａ１及び曲線Ａ２がそれぞれより現実的なフォーカス誤差を現わしている。メータＦの値が小さく露光面の凹凸の周期が小さいときには、スキャン方向のレベリング制御の追従性は悪く（曲線Ａ２）、凹凸の周期が大きくなるにつれて、スキャン方向のレベリング制御が曲がりに追従するようになることが分かる。また、非スキャン方向に対してはスキャン方向の様に逐次フォーカス位置が変わらない為、曲がりの周期が大きくなっても、スキャン方向の追従性より悪い（曲線Ａ１）。以上のように、パラメータＳが０．５以下になるようにフォーカス誤差がなることが望ましいが、スキャン方向及び非スキャン方向共に全体としてフォーカス誤差が大きい。

【００３１】一方、図１７（ｂ）は、スキャン方向のレベリングの応答周波数ｆｍが非スキャン方向のレベリングの応答周波数ｆｎより大きく、且つ両応答周波数ｆｍ及びｆｎが小さい場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ３は非スキャン方向での誤差パラメータＳ、曲線Ｂ３は非スキャン方向の通常のフォーカス誤差の平均値の絶対値、曲線Ａ４はスキャン方向での誤差パラメータＳ、曲線Ｂ４はスキャン方向での通常のフォーカス誤差の平均値の絶対値を示す。図１７（ａ）と図１７（ｂ）との比較より、ほぼ完全応答（図１７（ａ））の場合よりも応答周波数が小さい（図１７（ｂ））場合の方が、誤差パラメータＳが０．５に近くなっており、フォーカス誤差は小さいことが分かる。これは、感光基板上の細かい凸凹にオートレベリング機構が追従すると、スリット状の露光フィールド２４内で精度が悪化する点が発生するためである。但し、応答周波数を小さくし過ぎると、低周波の凸凹部まで追従できなくなるため、応答周波数は適当な値に設定する必要がある。

【００３２】また、図１７（ｂ）の例では、スキャン方向のレベリングの応答周波数ｆｍが非スキャン方向のレベリングの応答周波数ｆｎより高く設定されている。これは、同じ曲がりパラメータＦの凹凸であっても、スキャン方向ではスリット幅に応じて実質的に周期が短くなるため、良好に露光面の凹凸に追従するための応答周波数は、非スキャン方向よりもスキャン方向で高くする必要があるためである。

【００３３】また、オートレベリング機構用の多点計測手段が、その所定形状の照明領域と投影光学系（８）に関して共役な露光領域（２４）内の複数の点及びその共役な露光領域内に対して感光基板（５）が走査される際の手前の領域内の複数の点よりなる複数の計測点において、感光基板（５）の高さをそれぞれ計測する場合には、手前の計測点において部分的にフォーカス位置の先読みが行われる。これを「分割先読み」と呼ぶ。従って、全部の計測点で先読みを行う手法（完全先読み）に

比べて、露光までに多点計測手段でフォーカス位置を読み取る際の長さ（助走距離）が短縮される。

【００３４】また、その多点計測手段が、感光基板（５）の１つのショット領域へ順次マスク（１２）のパターンを露光する過程において、順次それら複数の計測点の位置を変化させる場合には、例えばそのショット領域の端部では分割先読みを行い、そのショット領域の中央部以降では完全先読みを行い、露光位置検出部でオープン制御の確認を行う。これにより、レベリング精度を高精度に維持した状態で、ショット領域の端部での助走距離を短縮して露光のスループットを高めることができる。

【００３５】次に、本発明の第２の面位置設定装置におけるオートフォーカス制御について検討する。上述の良好なフィールド（Good Field）の概念を取り入れると、図１６に示すように、露光フィールド２４の中央部２４ａ内の各計測点のフォーカス位置の平均化処理を行って、そのフォーカス位置の平均値で示される面を投影光学系の像面に合わせるのでは、精度が悪化する可能性がある。即ち、図１８（ａ）は、感光基板の深さＨの凹部のある露光面５ａの各計測点のフォーカス位置の平均値に対応する面３４Ａを示し、その面３４Ａと凹部とのフォーカス方向の差ΔＺ３は、Ｈ／２より大きくなっている。

【００３６】これに対して本発明においては、露光面５ａ上の所定の計測領域内の各計測点のフォーカス位置の最大値と最小値とを求め、それら最大値と最小値との中間のフォーカス位置に対応する面を投影光学系の像面に合わせ込むようにする。図１８（ｂ）は、感光基板の深さＨの凹部のある露光面５ａにおける、各計測点のフォーカス位置の内の最大値Z_{max}と最小値Z_{min}との中間のフォーカス位置に対応する面３４Ｂを示し、面３４Ｂのフォーカス位置Z_{34B}は次のように表すことができる。

$$Z_{34B}=(Z_{max}+Z_{min})/2 \quad (3)$$

【００３７】その後、その面３４Ｂが投影光学系の像面に合わせ込まれる。また、面３４Ｂと露光面５ａの表面とのフォーカス方向の差ΔＺ４と、面３４Ｂとその凹部とのフォーカス方向の差ΔＺ５とは、それぞれほぼＨ／２になっている。即ち、図１８（ａ）の面３４Ａに比べて図１８（ｂ）の面３４Ｂの方が、露光面５ａ上の各点におけるフォーカス位置の誤差の最大値が小さくなるため、良好なフィールド（Good Field）の概念上では、本発明により感光基板の露光面をより高精度に投影光学系の像面に合わせ込むことができる。

【００３８】更に、図１７（ａ）のように、スキャン方向のレベリングの応答周波数ｆｍと非スキャン方向のレベリングの応答周波数ｆｎとを等しく且つ大きくしてオートレベリング制御を行うと同時に、図１８（ａ）の平均化処理に基づくオートフォーカス制御又は図１８（ｂ）の最大値と最小値との平均値に基づくオートフォーカス制御を施した場合の、曲がりパラメータＦに対する誤差パラメータＳの特性をそれぞれ図１９（ａ）及び（ｂ）に示す。即ち、平均化処理に基づく図１９（ａ）において、曲線Ａ５及びＢ５はそれぞれ非スキャン方向の誤差パラメータＳ、曲線Ａ６及びＢ６はそれぞれスキャン方向の誤差パラメータＳを表す。また、最大値と最小値との平均値に基づく図１９（ｂ）において、曲線Ａ７及びＢ７はそれぞれ非スキャン方向の誤差パラメータＳ、曲線Ａ８及びＢ８はそれぞれスキャン方向の誤差パラメータＳを表す。

【００３９】図１９（ｂ）より明かなように、最大値と最小値との平均値に基づいてオートフォーカス制御を施した場合には、全ての曲がりパラメータＦ、即ちあらゆる周波数帯において、誤差パラメータＳの値が０．５に近くなっていると共に、平均化処理に基づいてオートフォーカス制御を施した場合に比べてフォーカス誤差の最大値が小さくなっている。

【００４０】また、図１５（ａ）及び（ｂ）に戻り、所定の計測領域内の計測点で得られたフォーカス位置の最大値と最小値との平均値に基づいてオートフォーカス制御のみを施した場合には、図１５（ａ）に示すように、振幅２・ΔＺａの曲がりを有する露光面５ａに対して、最大値とのフォーカス位置の差がΔＺａの面３６Ａが投影光学系の像面に合わせ込まれる。一方、振幅２・ΔＺａの曲がりを有する露光面５ａに対して、単にそれら計測点で得られたフォーカス位置の平均値に基づいてオートフォーカス制御を行うと共に、得られたフォーカス位置の最小自乗近似に基づいてオートレベリング制御を行うと、図１５（ｂ）に示すように、振幅ΔＺｃ（＞２・ΔＺａ）の範囲内で最大値からのフォーカス位置の差がΔＺｂ（＞ΔＺａ）の面３６Ｂが投影光学系の像面に合わせ込まれることがある。従って、オートレベリング機構を使用する場合でも使用しない場合でも、得られたフォーカス位置の最大値と最小値との平均値に基づいてオートフォーカス制御を行う方がフォーカス誤差が小さくなる。

【００４１】なお、本発明では、（フォーカス位置の最大値Z_{max}＋フォーカス位置の最小値Z_{min}）／２で定まる面を像面に合わせ込むように制御しているが、デバイス工程によっては感光基板の露光面５ａの凸部又は凹部の何れかの焦点深度が要求される場合もある。従って、所定の係数Ｍ及びＮを用いて、次式のような比例配分で定まるフォーカス位置Z_{MN}の面を像面に合わせるような制御を行うことが望ましい。

$$Z_{MN}=(M\cdot Z_{max}+N\cdot Z_{min})/(M+N) \quad (4)$$

【００４２】

【実施例】以下、本発明の一実施例につき図面を参照し

て説明する。本実施例は、スリットスキャン露光方式の投影露光装置のオートフォーカス機構及びオートレベリング機構に本発明を適用したものである。図１は本実施例の投影露光装置を示し、この図１において、図示省略された照明光学系からの露光光ＥＬによる矩形の照明領域（以下、「スリット状の照明領域」という）によりレチクル１２上のパターンが照明され、そのパターンの像が投影光学系８を介してウエハ５上に投影露光される。この際、露光光ＥＬのスリット状の照明領域に対して、レチクル１２が図１の紙面に対して手前方向（又は向こう側）に一定速度Ｖで走査されるのに同期して、ウエハ５は図１の紙面に対して向こう側（又は手前方向）に一定速度Ｖ／β（１／βは投影光学系８の縮小倍率）で走査される。

【００４３】レチクル１２及びウエハ５の駆動系について説明するに、レチクル支持台９上にＹ軸方向（図１の紙面に垂直な方向）に駆動自在なレチクルＹ駆動ステージ１０が載置され、このレチクルＹ駆動ステージ１０上にレチクル微小駆動ステージ１１が載置され、レチクル微小駆動ステージ１１上にレチクル１２が真空チャック等により保持されている。レチクル微小駆動ステージ１１は、投影光学系８の光軸に垂直な面内で図１の紙面に平行なＸ方向、Ｙ方向及び回転方向（θ方向）にそれぞれ微小量だけ且つ高精度にレチクル１２の位置制御を行う。レチクル微小駆動ステージ１１上には移動鏡２１が配置され、レチクル支持台９上に配置された干渉計１４によって、常時レチクル微小駆動ステージ１１のＸ方向、Ｙ方向及びθ方向の位置がモニターされている。干渉計１４により得られた位置情報Ｓ１が主制御系２２Ａに供給されている。

【００４４】一方、ウエハ支持台１上には、Ｙ軸方向に駆動自在なウエハＹ軸駆動ステージ２が載置され、その上にＸ軸方向に駆動自在なウエハＸ軸駆動ステージ３が載置され、その上にＺレベリングステージ４が設けられ、このＺレベリングステージ４上にウエハ５が真空吸着によって保持されている。Ｚレベリングステージ４上にも移動鏡７が固定され、外部に配置された干渉計１３により、Ｚレベリングステージ４のＸ方向、Ｙ方向及びθ方向の位置がモニターされ、干渉計１３により得られた位置情報も主制御系２２Ａに供給されている。主制御系２２Ａは、ウエハ駆動装置２２Ｂ等を介してウエハＹ軸駆動ステージ２、ウエハＸ軸駆動ステージ３及びＺレベリングステージ４の位置決め動作を制御すると共に、装置全体の動作を制御する。

【００４５】また、ウエハ側の干渉計１３によって計測される座標により規定されるウエハ座標系と、レチクル側の干渉計１４によって計測される座標により規定されるレチクル座標系の対応をとるために、Ｚレベリングステージ４上のウエハ５の近傍に基準マーク板６が固定されている。この基準マーク板６上には各種基準マークが形成されている。これらの基準マークの中にはＺレベリングステージ４側に導かれた照明光により裏側から照明されている基準マーク、即ち発光性の基準マークも設けられている。

【００４６】本例のレチクル１２の上方には、基準マーク板６上の基準マークとレチクル１２上のマークとを同時に観察するためのレチクルアライメント顕微鏡１９及び２０が装備されている。この場合、レチクル１２からの検出光をそれぞれレチクルアライメント顕微鏡１９及び２０に導くための偏向ミラー１５及び１６が移動自在に配置され、露光シーケンスが開始されると、主制御系２２Ａからの指令のもとで、ミラー駆動装置１７及び１８によりそれぞれ偏向ミラー１５及び１６は待避される。

【００４７】図１のスリットスキャン方式の投影露光装置に、図２０及び図２１を参照して説明した従来方式の斜め入射型の多点フォーカス位置検出系を装着する。但し、本例の多点フォーカス位置検出系は、計測点の個数が従来例よりも多いと共に、計測点の配置が工夫されている。図２（ｂ）は、図２１（ｂ）の従来のパターン形成板６２に対応する本例のパターン形成板６２Ａを示し、図２（ｂ）に示すように、パターン形成板６２Ａの第１列目には９個のスリット状の開口パターン７２－１１～７２－１９が形成され、第２列目～第５列目にもそれぞれ９個の開口パターン７２－１２～７２－５９が形成されている。即ち、パターン形成板６２Ａには、合計で４５個のスリット状の開口パターンが形成されており、これらのスリット状の開口パターンの像が図１のウエハ５の露光面上にＸ軸及びＹ軸に対して斜めに投影される。

【００４８】図２（ａ）は、本例の投影光学系８の下方のウエハ５の露光面を示し、この図２（ａ）において、投影光学系８の円形の照明視野２３に内接するＸ方向に長い矩形の露光フィールド２４内に図１のレチクル１２のパターンが露光され、この露光フィールド２４に対してＹ方向にウエハ５が走査（スキャン）される。本例の多点フォーカス位置検出系により、露光フィールド２４のＹ方向の上側のＸ方向に伸びた第１列の９個の計測点ＡＦ１１～ＡＦ１９、第２列の計測点ＡＦ２１～ＡＦ２９、露光フィールド２４内の第３列の計測点ＡＦ３１～ＡＦ３９、露光フィールド２４のＹ方向の下側の第４列の計測点ＡＦ４１～ＡＦ４９及び第５列の計測点ＡＦ５１～ＡＦ５９にそれぞれスリット状の開口パターンの像が投影される。

【００４９】図２（ｃ）は、本例の多点フォーカス位置検出系の受光器６９Ａを示し、この受光器６９Ａ上に第１列目には９個の受光素子７５－１１～７５－１９が配置され、第２列目～第５列目にもそれぞれ９個の受光素子７５－１２～７５－５９が配置されている。即ち、受光器６９Ａには、合計で４５個の受光素子が配列されて

おり、各受光素子上にはスリット状の絞り（図示省略）が配置されている。また、それら受光素子75－11～75－59上にそれぞれ図2（a）の計測点AF11～AF59に投影されたスリット状の開口パターンの像が再結像される。そして、ウエハ5の露光面で反射された光を、図20の回転方向振動板67に対応する振動板で回転振動することで、受光器69A上では再結像された各像の位置が絞りの幅方向であるRD方向に振動する。

【0050】各受光素子75－11～75－59の検出信号が信号処理装置71Aに供給され、信号処置装置71Aではそれぞれの検出信号を回転振動周波数の信号で同期検波することにより、ウエハ上の各計測点AF11～AF59のフォーカス位置に対応する45個のフォーカス信号を生成し、これら45個のフォーカス信号の内の所定のフォーカス信号より後述のように、ウエハの露光面の傾斜角（レベリング角）及び平均的なフォーカス位置を算出する。これら計測されたレベリング角及びフォーカス位置は図1の主制御系22Aに供給され、主制御系22Aは、その供給されたレベリング角及びフォーカス位置に基づいて駆動装置22B及びZレベリングステージ4を介してウエハ5のレベリング角及びフォーカス位置の設定を行う。

【0051】従って、本例では図2（a）に示す45個の全ての計測点AF11～AF59のフォーカス位置を計測することができる。但し、本例では、図3に示すように、ウエハのスキャン方向に応じてそれら45個の計測点中で実際にフォーカス位置を計測する点（以下、「サンプル点」という）の位置を変えている。一例として、図3（a）に示すように、露光フィールド24に対してY方向にウエハをスキャンする場合で、且つ後述のような分割先読みを行う場合には、第2列25Bの計測点中の奇数番目の計測点AF21，AF23，‥‥，AF29及び露光フィールド24内の偶数番目の計測点AF32，AF34，‥‥，AF38がサンプル点となる。また、図3（b）に示すように、露光フィールド24に対して－Y方向にウエハをスキャンする場合で、且つ後述のような分割先読みを行う場合には、第4列25Dの計測点中の奇数番目の計測点AF41，AF43，‥‥，AF49及び露光フィールド24内の偶数番目の計測点AF32，AF34，‥‥，AF38がサンプル点となる。

【0052】更に、スリットスキャン露光時のフォーカス位置の計測結果は、ウエハ側のステージの移動座標に応じて逐次変化していくため、それらフォーカス位置の計測結果は、ステージのスキャン方向の座標及び非スキャン方向の計測点の座標よりなる2次元のマップとして図1の主制御系22A内の記憶装置に記憶される。このように記憶された計測結果を用いて、露光時のウエハのフォーカス位置及びレベリング角が算出される。そして、実際に図1のZレベリングステージ4を駆動してウエハの露光面のフォーカス位置及びレベリング角を設定する場合は、計測結果に従ってオープンループ制御によりZレベリングステージ4の動作が制御される。この場合、予め計測された結果に基づいて露光フィールド24内での露光が行われる。即ち、図4（a）に示すように、例えば第2列25Bの計測点の所定のサンプリング点でウエハ上の領域26のフォーカス位置の計測が行われ、その後図4（b）に示すようにウエハ上の領域26が露光フィールド24内に達したときに、図4（a）での計測結果に基づいて、ウエハ上の領域26のフォーカシング及びレベリング制御が行われる。

【0053】図5は本例のZレベリングステージ4及びこの制御系を示し、この図5において、Zレベリングステージ4の上面部材は下面部材上に3個の支点28A～28Cを介して支持されており、各支点28A～28Cはそれぞれフォーカス方向に伸縮できるようになっている。各支点28A～28Cの伸縮量を調整することにより、Zレベリングステージ4上のウエハ5の露光面のフォーカス位置、スキャン方向の傾斜角θ_Y 及び非スキャン方向の傾斜角θ_X を所望の値に設定することができる。各支点28A～28Cの近傍にはそれぞれ、各支点のフォーカス方向の変位量を例えば0．01μm程度の分解能で計測できる高さセンサー29A～29Cが取り付けられている。なお、フォーカス方向（Z方向）への位置決め機構として、よりストロークの長い高精度な機構を別に設けても良い。

【0054】Zレベリングステージ4のレベリング動作を制御するために、主制御系22Aはフィルタ部30A及び30Bにそれぞれ刻々に変化する非スキャン方向の設定すべき傾斜角θ_X 及びスキャン方向の設定すべき傾斜角θ_Y を供給する。フィルタ部30A及び30Bはそれぞれ異なるフィルタ特性でフィルタリングして得られた傾斜角を演算部31に供給し、主制御系22Aは演算部31にはウエハ5上の露光対象とする領域の座標W（X，Y）を供給する。演算部31は、座標W（X，Y）及び2つの傾斜角に基づいて駆動部32A～32Cに設定すべき変位量の情報を供給する。各駆動部32A～32Cにはそれぞれ高さセンサー29A～29Cから支点29A～29Cの現在の高さの情報も供給され、各駆動部32A～32Cはそれぞれ支点29A～29Cの高さを演算部31に設定された高さに設定する。

【0055】これにより、ウエハ5の露光面のスキャン方向の傾斜角及び非スキャン方向の傾斜角がそれぞれ所望の値に設定されるが、この際にフィルタ部30A及び30Bの特性の相違により、スキャン方向のレベリングの応答周波数fm［Hz］が非スキャン方向のレベリングの応答速度fn［Hz］よりも高めに設定されている。一例としてスキャン方向のレベリングの応答周波数fmは10Hz、非スキャン方向のレベリングの応答速度fnは2Hzである。

【0056】また、支点28A，28B及び28Cが配置されている位置をそれぞれ駆動点TL1，TL2及びTL3と呼ぶと、駆動点TL1及びTL2はY軸に平行な1直線上に配置され、駆動点TL3は駆動点TL1とTL2との垂直2等分線上に位置している。そして、投影光学系によるスリット状の露光フィールド24が、ウエハ5上のショット領域SA_{ij}上に位置しているものとすると、本例では、支点28A～28Cを介してウエハ5のレベリング制御を行う際に、そのショット領域SA_{ij}のフォーカス位置は変化しない。従って、レベリング制御とフォーカス制御とが分離した形で行われるようになっている。また、ウエハ5の露光面のフォーカス位置の設定は、3個の支点28A～28Cを同じ量だけ変位させることにより行われる。

【0057】次に、本例のレベリング動作及びフォーカシング動作につき詳細に説明する。先ず、レベリング用の傾斜角及びフォーカシング用のフォーカス位置の算出法を示す。

（A）傾斜角の算出法

図4に示すように、各列の計測点において非スキャン方向のm番目のサンプル点のX座標をX_m、スキャン方向のn番目のサンプル点のY座標をY_nとして、X座標X_m及びY座標Y_nのサンプル点で計測されたフォーカス位置の値をAF（X_m，Y_n）で表す。また、非スキャン方向のサンプル数をM、スキャン方向のサンプリング数をNとして、次の演算を行う。但し、和演算Σ_mは添字mに関する1～Mまでの和を表す。

【0058】

$$SX=\Sigma_m X_m,\ SX2=\Sigma_m X_m^2,\ SMZ=\Sigma_m AF(X_m, Y_n),$$
$$SXZ=\Sigma_m (AF(X_m, Y_n)\cdot X_m) \quad (5)$$

同様に、和演算Σ_nが添字nに関する1～Nまでの和を表すものとして、次の演算を行う。

$$SY=\Sigma_n Y_n,\ SY2=\Sigma_n Y_n^2,\ SNZ=\Sigma_n AF(X_m, Y_n),$$
$$SYZ=\Sigma_n (AF(X_m, Y_n)\cdot Y_n) \quad (6)$$

【0059】そして、（5）式及び（6）式を用いて次の演算を行う。

$$An=(SX\cdot SMZ-M\cdot SXZ)/(SX^2-M\cdot SX2) \quad (7)$$
$$Am=(SY\cdot SNZ-N\cdot SYZ)/(SY^2-N\cdot SY2) \quad (8)$$

次に、各Anより、最小自乗近似によりスキャン方向のn番目のサンプル点における非スキャン方向（X方向）の傾斜角AL（Y_n）を求め、各Amより、最小自乗近似により非スキャン方向のm番目のサンプル点におけるスキャン方向（Y方向）の傾斜角AL（X_m）を求める。その後、次のような平均化処理により非スキャン方向の傾斜角θ_X及びスキャン方向の傾斜角θ_Yを求める。

$$\theta_X=(\Sigma_n AL(Y_n))/N \quad (9)$$
$$\theta_Y=(\Sigma_m AL(X_m)) \quad (10)$$

【0060】（B）フォーカス位置算出法

フォーカス位置の算出法には平均化処理法と最大最小検出法とがあり、本例では最大最小検出法でフォーカス位置を算出する。参考のため、平均化処理法では、上述のフォーカス位置の値AF（X_m，Y_n）を用いて、次式よりウエハ5の露光面の全体としてのフォーカス位置〈AF〉を計算する。

$$\langle AF\rangle=(\Sigma_n \Sigma_m AF(X_m, Y_n))/(M\cdot N) \quad (11)$$

【0061】次に、最大最小検出法では、最大値及び最小値を表す関数をそれぞれMax（ ）及びMin（ ）として、次式よりウエハ5の露光面の全体としてのフォーカス位置AF′を計算する。

$$AF'=(Max(AF(X_m, Y_n))+Min(AF(X_m, Y_n))/2 \quad (12)$$

そして、図4（b）に示すように、計測された領域26が露光フィールド24に達したときには、（9）式、（10）式、（12）式の検出結果θ_X，θ_Y及びAF′に基づいて、図5の3個の支点28A～28Cがそれぞれ高さセンサー29A～29Cの計測結果を基準としてオープンループで駆動される。具体的に、オートフォーカス制御は、3個の支点28A～28Cを同時に駆動することにより実行され、オートレベリング制御は、図5に示す露光フィールド24内のフォーカス位置が変化しないように実行される。

【0062】即ち、図5において、露光フィールド24の中心点と支点28A，28BのX方向の間隔をX_1、露光フィールド24の中心点と支点28CのX方向の間隔をX_2、露光フィールド24の中心点と支点28AのY方向の間隔をY_1、露光フィールド24の中心点と支点28BのY方向の間隔をY_2として、非スキャン方向の傾斜角θ_Xの結果に基づき、支点28A，28Bと支点28Cとにそれぞれ$X_1:X_2$との比で逆方向の変位が与えられ、スキャン方向の傾斜角θ_Yの結果に基づき、支点28Aと支点28Bとにそれぞれ$Y_1:Y_2$との比で逆方向の変位が与えられる。

【0063】また、上記処理法では、フォーカス位置及び傾斜角が露光装置に応じて刻々変化するので実際のフォーカス位置の計測値を補正する必要がある。図6（a）は、或るフォーカス位置の計測点（AF点）でウエハの露光面5a上の領域26の全体としてのフォーカス位置及び傾斜角を計測している状態を示し、図6（a）の状態では、図5の各駆動点TL1～TL3にある支点のフォーカス方向の駆動量〈TL1〉，〈TL2〉及び〈TL3〉はそれぞれ0（基準位置）であると

する。そして、その領域２６が図６（ｂ）に示すように、露光フィールド内の露光点に達したときには、露光のためにそれら駆動量はそれぞれ、〈ＴＬ１〉＝ａ，〈ＴＬ２〉＝ｂ，〈ＴＬ３〉＝ｃ、に設定される。この場合、フォーカス位置の計測点（ＡＦ点）で計測されている領域２６Ａのフォーカス位置は、図６（ａ）の場合に比べてΔＦだけ変化しているが、このΔＦの変化量には各駆動点ＴＬ１～ＴＬ３における駆動量の影響が含まれているため、次に領域２６Ａの露光を行う場合には、図６（ｂ）の状態での各駆動点ＴＬ１～ＴＬ３の駆動量を補正する形でレベリング及びフォーカシングを行う必要がある。

【００６４】即ち、領域２６に関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角をそれぞれF_1、θ_{1X}及びθ_{1Y}として、領域２６Ａに関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角をそれぞれF_0'、θ_{0X}'及びθ_{0Y}'とする。また、フォーカス位置の計測点（ＡＦ点）と露光点とのＸ方向及びＹ方向の間隔をそれぞれΔＸ及びΔＹとすると、フォーカス位置の補正量ΔＦ１は次のようになる。

$\Delta F1 = -F_1 - \theta_{1X} \cdot \Delta X - \theta_{1Y} \cdot \Delta Y$　（１３）

【００６５】その補正量ΔＦ１を用いると、領域２６Ａに関して計測されたフォーカス位置、Ｘ方向の傾斜角及びＹ方向の傾斜角のそれぞれの補正後の値F_0、θ_{0X}及びθ_{0Y}は次のようになる。

$F_0 = F_0' + \Delta F1$　（１４）

$\theta_{0X} = \theta_{0X}' - \theta_{1X}$　（１５）

$\theta_{0Y} = \theta_{0Y}' - \theta_{1Y}$　（１６）

また、ウエハ５の露光面の高周波の凸凹面に対しては追従しない様に応答性を管理する必要がある。即ち、ウエハ５の走査速度が変わった場合も、ステージ位置に対応した応答が要求されるので、計測されたフォーカス位置及び傾斜角を高速フーリエ変換（ＦＦＴ）用の数値フィルターで管理するか、図５の３個の支点２８Ａ～２８Ｃの駆動部のサーボゲインを速度に応じて可変できる機構にする。但し、ＦＦＴ用の数値フィルターは予備スキャンが必要で、サーボゲインは位相遅れがあるので、これらを考慮した機構が必要である。

【００６６】（Ｃ）サーボゲイン可変法

ここでは図５の３個の支点２８Ａ～２８Ｃの駆動部のサーボゲインを速度に応じて可変する方法の一例につき説明する。ウエハの走査速度がＶ／βのときの応答周波数をνとすると、伝達関数Ｇ（ｓ）は以下の様に表される。

$G(s) = 1/(1 + Ts)$　（１７）

但し、$T = 1/(2\pi\nu)$、$s = 2\pi f i$、である。

【００６７】解析結果より、走査速度Ｖ／βが８０mm／ｓの場合、非スキャン方向の応答周波数νは２Ｈｚが最適で、スキャン方向の応答周波数νは１０Ｈｚが最適であることが分かった。但し、ウエハの露光面の凸凹をピッチｐの正弦波で表し、ウエハ上の各ショット領域の走査方向の長さをL_0とすると、（１７）式中の周波数ｆは次のようになる。

$f = (V/\beta)/L_0 \cdot (L_0/p) = (V/\beta)/p$　（１８）

従って、走査速度Ｖ／βが変化すると周波数ｆも変化するので、最適な応答周波数νを新たに求める必要がある。このようにして求めた応答周波数νよりサーボゲインを決定する。

【００６８】（Ｄ）数値フィルタリング法

ここでウエハの露光面上の凹凸のピッチｐは、ステージ位置に依存した関数なので、フォーカス位置のサンプリングをステージ位置に同期して位置基準で行うと、走査速度Ｖ／βに依存しない制御が可能になる。即ち、位置関数で伝達関数Ｇ（ｓ）と同等のフィルタリング効果を持たせるためには、伝達関数Ｇ（ｓ）を逆フーリエ変換して位置関数Ｆ（ｘ）を求め、この位置関数Ｆ（ｘ）を用いて数値フィルタリングを行う。具体的に応答周波数νの伝達関数Ｇ（ｓ）の一例を図７（ａ）に示し、それに対応する位置関数Ｆ（ｘ）を図７（ｂ）に示す。但し、数値フィルタリング時は助走スキャン距離をとる必要があり、これを行わない場合は位相遅れが生じる。

【００６９】なお、上述のサーボゲイン可変法及び数値フィルタリング法の内の何れの方法においても、位相遅れとフィルタリング効果とで応答性を管理する。位相遅れ（時間遅れ）とは、図１５（ｃ）の曲線３７Ａで示される目標とするフォーカス位置に対応する信号と、曲線３８Ａで示される実際に計測されたフォーカス位置に対応する信号との間に存在する時間遅れである。フィルタリング効果とは、図１５（ｄ）の曲線３７Ｂ及び３８Ｂで示すように、目標とするフォーカス位置に対して実際のフォーカス位置の振幅を所定量だけ小さくすることである。

【００７０】上述のように、本例ではウエハの各ショット領域への露光を行う際に、予備的な走査である助走スキャンを行う場合がある。そこで、その助走スキャン距離の設定方法について説明する。図８（ａ）は、ウエハ上のショット領域SA_{11}の露光を終わってから、順次隣りのショット領域SA_{12}及びSA_{13}へレチクルのパターンを露光する場合の走査方法を示す。この図８（ａ）において、ウエハを－Ｙ方向に走査して、ウエハ上のショット領域SA_{11}への露光が終わってから、加減速期間T_{11}の間にウエハをＸ軸及びＹ軸に対して斜めに移動させて、次のショット領域SA_{12}の下端の近傍を投影光学系の露光フィールドに配置する。最初のショット領域SA_{11}への露光が終わってから、次のショット領域SA_{12}の下端の近傍へ移動する間にＹ方向へ間隔ΔＬの移動が行われる。また、その加減速期間T_{Y1}の終期において、ウエハのＹ方向への移動が開始される。

【００７１】その後の制定（整定）期間T_{W2}の間に、ウエハの走査速度がほぼＶ／βに達し、それに続く露光期間T_{W3}の間にショット領域SA_{12}へのレチクルのパターンの露光が行われる。この場合の、ウエハ側での加減速期間T_{W1}、制定期間T_{W2}及び露光期間T_{W3}を図８（ｃ）に示し、レチクル側での加減速期間T_{R1}、制定期間T_{R2}及び露光期間T_{R3}を図８（ｂ）に示す。なお、レチクル側では図８（ａ）のように隣りのショット領域へ移動する必要がないため、レチクル側のステージの移動はＹ軸に沿う往復運動である。また、ウエハ側では、図８（ｃ）に示すように、加減速期間T_{W1}から制定期間T_{W2}へ移行する程度の時点t_0から、多点フォーカス位置検出系によるフォーカス位置のサンプリングが開始される。

【００７２】本例では位相遅れとフィルタリング効果とで、レベリング及びフォーカシング時の応答性を管理するので、ウエハ上でフォーカス位置のサンプリングを開始するときの開始点が、状況によって異なってくる。例えば、サンプリングをステージ位置に同期させるものとして、数値フィルタリングを行うとすると、次の手順でサンプリング開始位置が決定される。

【００７３】先ず、図７（ａ）のように伝達関数Ｇ（ｓ）が与えられ、この伝達関数Ｇ（ｓ）より逆フーリエ変換で図７（ｂ）の位置関数Ｆ（ｘ）を求め、この位置関数Ｆ（ｘ）の原点からゼロクロス点までの長さΔＬを求める。この長さΔＬが、図８（ａ）に示すように、隣りのショット領域SA_{12}への露光のために斜めに移動する際のＹ方向への移動量ΔＬと等しい。

【００７４】また、レチクルの加減速期間T_{R1}に対して、ウエハの加減速期間T_{W1}が小さいため、時間（T_{R1}－T_{W1}）はウエハ側の待ち時間となる。この場合、ΔＬ＜（Ｖ／β）（T_{R1}－T_{W1}）、のときはスループットの低下にならないが、ΔＬ＞（Ｖ／β）（T_{R1}－T_{W1}）、のときはスループットの低下となる。なお、ΔＹ＝ΔＬ－（Ｖ／β）（T_{R1}－T_{W1}）、で表される長さΔＹは位相遅れとして処理しても、伝達関数Ｇ（ｓ）と同様のフィルタリング効果が得られれば、固定関数として良い。これらのフィルタリングを行うことにより、多点フォーカス位置検出系に対する空気揺らぎや、多点フォーカス位置検出系の制御誤差の影響を低減する効果も期待できる。

【００７５】次に、本例のスリットスキャン露光方式の投影露光装置における、多点フォーカス位置検出系の計測点中のサンプル点の配置を検討する。先ず、図２（ａ）において、多点フォーカス位置検出系による計測点ＡＦ１１～ＡＦ５９の内で、スリット状の露光フィールド２４内の計測点ＡＦ３１～ＡＦ３９のフォーカス位置の計測結果を用いる場合、即ち計測点ＡＦ３１～ＡＦ３９をサンプル点とする場合には、従来のステッパーの場合と同様の「露光位置制御法」による制御が行われる。更に、本例のウエハのスキャンはＹ方向又は－Ｙ方向へ行われるので、露光フィールド２４に対して走査方向の手前に計測点中のサンプルを配置することで、先読み制御、時分割レベリング計測、及び計測値平均化等が可能になる。

【００７６】先読み制御とは、図２（ａ）によるのウエハを露光フィールド２４に対して－Ｙ方向にスキャンする場合には、走査の手前の計測点ＡＦ４１～ＡＦ４９，ＡＦ５１～ＡＦ５９中からもサンプル点を選択することを意味する。先読み制御を行うことにより、オートフォーカス機構及びオートレベリング機構の伝達関数Ｇ（ｓ）に対して、実際の応答周波数に対する追従誤差は｜１－Ｇ（ｓ）｜となる。但し、この追従誤差には位相遅れとフィルタリング誤差要因とが入っているので、先読み制御を行えば、位相遅れを除去できることになる。この誤差は１－｜Ｇ（ｓ）｜なので、約４倍の伝達能力を持たせる事が出来る。

【００７７】図９（ａ）は従来と同様の露光位置制御を行った場合の目標とするフォーカス位置に対応する曲線３９Ａ及び実際に設定されたフォーカス位置に対応する曲線３８Ｂを示し、図９（ｂ）は先読み制御を行った場合の目標とするフォーカス位置に対応する曲線４０Ａ及び実際に設定されたフォーカス位置に対応する曲線４０Ｂを示し、露光位置制御では位相がずれている。従って、露光位置制御の場合の目標位置と追従位置との差Ｆａは、先読み制御の場合の目標位置と追従位置との差Ｆｂの約４倍となる。従って、先読み制御では約４倍の伝達能力をもたせることができる。

【００７８】しかし、既に述べた様に、オートレベリングの応答周波数はスキャン方向で１０Ｈｚ程度が適当（位置制御法では）なので、先読み制御を行うと、スキャン方向では２．５Ｈｚ程度のフィルタリング応答で良いことになる。このフィルタリングを数値フィルタ又は制御ゲインによって行うと、ウエハの走査速度を８０ｍｍとして、５（≒80/(2π*2.5)）ｍｍ程度の助走スキャン長が、露光前に必要になる。以下に両制御法による、フォーカス誤差を示す。

【００７９】そのため、図１７の場合と同様に、ウエハ上のショット領域SA_{11}のスキャン方向の周期的な曲がりの周期を、スキャン方向の幅との比の値として曲がりパラメータＦで表し、その周期的な曲がりがあるときの各計測点でのフォーカス誤差を、各計測点でのフォーカス位置の誤差の平均値の絶対値と、フォーカス位置の誤差の振幅の１／３との和で表す。また、曲がりパラメータＦの周期的な曲がりの振幅を１に規格化し、曲がりパラメータがＦであるときの、それら各計測点でのフォーカス誤差の内の最大値を示す誤差パラメータＳを、曲がりパラメータＦに対する比率として表す。

【００８０】図１０（ａ）は、露光位置制御を行った場合で、且つスキャン方向のレベリングの応答周波数ｆｍ

が１０Ｈｚ、非スキャン方向のレベリングの応答周波数ｆｎが２Ｈｚの場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ９及びＢ９は共に非スキャン方向での誤差パラメータＳ、曲線Ａ１０及びＢ１０は共にスキャン方向での誤差パラメータＳを示す。一方、図１７（ｂ）は、先読み制御を行った場合で、且つスキャン方向のレベリングの応答周波数ｆｍが２．５Ｈｚ、非スキャン方向のレベリングの応答周波数ｆｎが０．５Ｈｚの場合の曲がりパラメータＦに対する誤差パラメータＳを表し、曲線Ａ１１及びＢ１１は共に非スキャン方向での誤差パラメータＳ、曲線Ａ１２及びＢ１２は共にスキャン方向での誤差パラメータＳを示す。

【００８１】以上の様に先読み制御で位相遅れを除去することは、応答を向上するためには良いが、応答を低下させる場合には適さない。しかし、先読み制御はソフトウェア的に自由度が多く、図１１で示すような時間的平均化及び露光開始時でのフォーカス位置の計測点の予測設定を行うこともできる。即ち、図１１（ａ）において、ウエハの露光面５ａ上の或る領域２６Ｂに対して多点フォーカス位置検出系の走査方向に対して手前のサンプル点（ＡＦ点）において、幅ΔＬの長さだけフォーカス位置が検出される。そして、図１１（ｂ）に示すように、領域２６Ｂが露光点に達したときには、幅ΔＬの範囲で検出されたフォーカス位置の情報を平均化して高精度にレベリング及びフォーカシングが行われる。

【００８２】また、図１１（ｃ）に示すように、露光位置制御法で計測点と露光点とが等しい場合で、ウエハの露光面５ａに段差部２６Ｃがあっても、図１１（ｄ）に示すように、フォーカス対象とする面（フォーカス面）ＡＦＰは次第に上昇するだけで、その段差部２６Ｃではデフォーカスされた状態で露光が行われる。これに対して、図１１（ｅ）に示すように、先読み制御法で計測点と露光点とが離れている場合で、ウエハの露光面５ａに段差部２６Ｄがあると、予めその段差に合わせて図１１（ｆ）に示すように、フォーカス面ＡＦＰを次第に上昇することにより、その段差部２６Ｄでは合焦された状態で露光が行われる。

【００８３】なお、先読み制御法のみならず、通常の露光位置制御法も備えておき、２つの制御法を選択可能なシステムにすることが望ましい。本例のオートフォーカス及びオートレベリング機構には、上述のような機能があるので、実際にウエハの露光面の制御を行うには、①露光位置制御、②完全先読み制御、③分割先読み制御よりなる３種類の制御法が考えられる。以下ではこれら３種類の制御法につき詳細に説明する。

（Ｆ）露光位置制御法

この方式ではオートフォーカス及びオートレベリング機構の応答性能を一切考慮せず、露光時に計測して得られたフォーカス位置の値を用いて、ウエハの露光面のフォーカス位置及びレベリング角の制御を行う。即ち、図１２（ａ）に示すように、露光フィールド２４に対して走査方向（Ｙ方向）に手前側の第２列２５Ｂの偶数番目の計測点をサンプル点４１として、露光フィールド２４内の第３列２５Ｃの奇数番目の計測点をもサンプル点とする。そして、第２列２５Ｂのサンプル点でのフォーカス位置の計測値と第３列２５Ｃのサンプル点でのフォーカス位置の計測値とから、ウエハの露光面のスキャン方向のレベリング制御を行う。

【００８４】また、第２列２５Ｂ及び第３列２５Ｃのサンプル点でのフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求めて、非スキャン方向のレベリング制御を行う。また、フォーカス制御は、露光フィールド２４内の第３列の計測点でのフォーカス位置の計測値も用いてフォーカス制御を行う。なお、図１２（ｂ）に示すように、ウエハのスキャン方向が－Ｙ方向である場合には、サンプル点は第３列２５Ｃ及び第４列２５Ｄの計測点から選択される。この方式では、最も制御が簡単であるが、ウエハのスキャン速度等により追従精度が変わってしまうという不都合がある。また、第２列２５Ｂ及び第３列２５Ｃの各計測点でのフォーカス位置のキャリブレーションが必要である。

【００８５】（Ｇ）完全先読み制御法

この方式では、図１２（ｃ）に示すように、露光フィールド２４に対して走査方向に手前側の第１列２５Ａの全ての計測点をサンプル点として、予め露光前に第１列２５Ａのサンプル点でのフォーカス位置の値を全て計測しておく。そして、平均化処理やフィルタリング処理を行い、位相遅れを見込んで露光時にオープンでオートフォーカス及びオートレベリング機構を制御する。即ち、第１列２５Ａの各サンプル点でのフォーカス位置の計測値を記憶しておき、時間軸上で計測されたフォーカス位置の値からスキャン方向の傾きを算出し、露光時にスキャン方向のレベリング制御をオープン制御で行う。

【００８６】それと並行して、第１列２５Ａの各サンプル点でのフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求め、非スキャン方向のレベリング制御をオープン制御で行う。先読みなので、時間軸での平均化も可能である。また、第１列２５Ａの各サンプル点でのフォーカス位置の計測値を記憶しておき、露光時にフォーカス合わせをオープン制御で行う。なお、図１２（ｄ）に示すように、ウエハの走査方向が－Ｙ方向の場合には、第５列２５Ｅの全ての計測点がサンプル点として選択される。

【００８７】この方式では、第１列２５Ａにおいてサンプル点が９点確保できるため、情報量が多く精度向上が期待できる。また、サンプル点は１ラインなのでキャリブレーションが不要である共に、応答性の管理ができるという利点がある。一方、第１列２５Ａのサンプル点に関してまともに計測を行うと、各ショット領域の端部の露光を行うために走査すべき距離（助走スキャン長）が

長くなり、スループットが低下する不都合がある。また、オープン制御なので、多点フォーカス位置検出系による確認ができないという不都合もある。

【００８８】（H）分割先読み制御法
この方式では、図１２（ｅ）に示すように、露光フィールド２４に対して走査方向（Y方向）に手前側の第２列２５Ｂの奇数番目の計測点をサンプル点として、露光フィールド２４内の第３列２５Ｃの偶数番目の計測点をもサンプル点とする。そして、第２列２５Ｂ及び第３列２５Ｃのサンプル点において、予め露光前にフォーカス位置の値を全て計測しておく。その後、平均化処理やフィルタリング処理を行い、位相遅れを見込んで露光時にオープン制御で制御を行う。即ち、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値を記憶しておき、時間軸上で計測されたフォーカス位置の値からスキャン方向の傾きを算出し、露光時にスキャン方向のレベリングをオープン制御で行う。

【００８９】また、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値から最小自乗近似法で非スキャン方向の傾きを求め、非スキャン方向のレベリングをオープン制御で行う。先読みなので、時間軸での平均化も可能である。また、第２列２５Ｂ及び第３列２５Ｃのサンプル点におけるフォーカス位置の計測値を記憶しておき、露光時にフォーカス合わせをオープン制御で行う。なお、図１２（ｆ）に示すように、ウエハのスキャン方向が－Y方向である場合には、サンプル点は第３列２５Ｃ及び第４列２５Ｄの計測点から選択される。

【００９０】この方式では、第２列２５Ｂ（又は第４列２５Ｄ）が露光フィールド２４に近接しているため、ウエハの各ショット領域の端部の露光を行うための助走スキャン距離を少なくできると共に、応答性の管理ができるという利点がある。また、露光時の第３列２５Ｃのサンプル点でのフォーカス位置の計測値から、オープン制御で露光面の制御を行った結果の確認が可能である。一方、第２列２５Ｂのサンプル点でのフォーカス位置と第３列のサンプル点でのフォーカス位置とのキャリブレーションが必要であるという不都合がある。

【００９１】また、完全先読み制御法では、図１３（ａ）～（ｄ）に示すように、露光開始、露光中及び露光終了間際のフォーカス位置のサンプル点を変えることによって、より正確なオートフォーカス及びオートレベリング制御を行っている。即ち、図１３（ａ）に示すように、露光すべきショット領域ＳＡが露光フィールド２４に対して間隔Ｄ（露光フィールド２４のスキャン方向の幅と同じ）の位置に達したときに、露光フィールド２４から間隔Ｄのサンプル領域４２で多点フォーカス位置検出系によるフォーカス位置の計測が開始される。幅Ｄ、即ち露光フィールド２４のスキャン方向の幅の一例は８mmである。その後、図１３（ｂ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に接触したときに、ウエハ上の２個のサンプル点間の検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、１個のサンプル点よりなる検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９２】次に、図１３（ｃ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に入ったときに、ウエハ上の２個のサンプル点間の検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、２個のサンプル点間の検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。また、図１３（ｄ）に示すように、ショット領域ＳＡが露光フィールド２４を覆うようになったときには、露光フィールド２４を覆う検出域４４でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、露光フィールド２４を覆う検出域４５でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９３】一方、分割先読み制御法でも、図１３（ｅ）～（ｈ）に示すように、露光開始、露光中及び露光終了間際のフォーカス位置のサンプル点を変えることによって、より正確なオートフォーカス及びオートレベリング制御を行っている。即ち、図１３（ｅ）に示すように、露光すべきショット領域ＳＡが露光フィールド２４に対して間隔Ｄ／２（露光フィールド２４のスキャン方向の幅の１／２）の位置に達したときに、露光フィールド２４から外側に間隔Ｄ／２のサンプル領域４３Ａ及び露光フィールド２４から内側に間隔Ｄ／２のサンプル領域４３Ｂで多点フォーカス位置検出系によるフォーカス位置の計測が開始される。その後、図１３（ｆ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に接触したときに、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、１個のサンプル点よりなる検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。

【００９４】次に、図１３（ｇ）に示すように、ショット領域ＳＡの先端部が露光フィールド２４に幅Ｄ／２だけ入ったときに、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、幅Ｄ／２の検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。また、図１３（ｈ）に示すように、ショット領域ＳＡが露光フィールド２４を覆うようになったときには、露光フィールド２４を覆う検出域４６でのフォーカス位置の計測値に基づいてスキャン方向のレベリング制御が行われ、露光フィールド２４を覆う検出域４７でのフォーカス位置の計測値に基づいてオートフォーカス制御が行われる。図１３より、分割先読み法では、助

走スキャン長（＝D／2）を完全先読み法に比べて1／2にできることが分かる。

【0095】なお、上述実施例においては、ウエハの露光面の多点のフォーカス位置を計測するために、2次元的に配列されたスリット状の開口パターン像をウエハ上に投影する多点フォーカス位置検出系が使用されている。しかしながら、その代わりに、非スキャン方向に細長いスリット状になっているパターンの像をウエハ上に投影し、その非スキャン方向の全体のフォーカス位置を計測する1次元のフォーカス位置検出系を使用しても良い。また、画像処理方式のフォーカス位置検出系を用いて、ウエハの露光面上の2次元的なフォーカス位置の分布を計測する場合でも、上述実施例と同様の分割先読み等を適用することにより、高精度なフォーカシング及びレベリングを行うことができる。更に、本例では図17より分かるように、非スキャン方向のレベリング誤差に対して、スキャン方向のレベリング誤差が小さいことから、スキャン方向のレベリング動作を行うことなく、非スキャン方向のみのレベリング動作を行っても良い。

【0096】なお、本発明は上述実施例に限定されず、本発明の要旨を逸脱しない範囲で種々の構成を取り得ることは勿論である。

【0097】

【発明の効果】本発明の第1の面位置設定装置によれば、スリットスキャン露光方式の投影露光装置において、感光基板の表面の凹凸、多点計測手段の計測精度、空気揺らぎ等による誤差を補正して、感光基板の露光面を投影光学系の像面に対して高精度に平行に合わせることができる利点がある。

【0098】また、多点計測手段が、基板側ステージを介して感光基板が走査されているときに、基板側ステージの位置基準で複数の計測点における感光基板の高さをサンプリングする場合には、より高精度に走査方向の傾斜角を計測できる。また、多点計測手段が、所定形状の照明領域と投影光学系に関して共役な露光領域内の複数の点及びその共役な露光領域内に対して感光基板が走査される際の手前の領域内の複数の点よりなる複数の計測点において、その感光基板の高さをそれぞれ計測する場合には、分割先読み制御により、露光の開始時の助走スキャン距離を短縮できる利点がある。

【0099】また、多点計測手段が、感光基板の1つのショット領域へ順次マスクのパターンを露光する過程において、順次複数の計測点の位置を変化させる場合には、例えば分割先読みと完全先読みとを併用することにより、レベリング精度及びスループットを共に改善することができる。また、本発明の第2の面位置設定装置によれば、スリットスキャン露光方式の投影露光装置において、感光基板の表面の凹凸、多点計測手段の計測精度、空気揺らぎ等による誤差を補正して、感光基板の露光面のフォーカス位置を投影光学系の像面に対して正確に合わせることができる利点がある。

【図面の簡単な説明】

【図1】本発明による面位置設定装置の一実施例が適用された投影露光装置を示す構成図である。

【図2】（a）は実施例において投影光学系による露光フィールドを含む領域に投影された2次元的なスリット状の開口パターン像を示す平面図、（b）は多点フォーカス位置検出系のパターン形成板上の開口パターンを示す図、（c）は受光器上の受光素子の配列を示す図である。

【図3】（a）は実施例で分割先読みを行う場合のサンプル点を示す図、（b）は逆方向にスキャンする場合で且つ分割先読みを行う場合のサンプル点を示す図である。

【図4】（a）はフォーカス位置を先読みする場合を示す図、（b）は先読みしたフォーカス位置を用いて露光を行う場合を示す図である。

【図5】実施例のオートフォーカス及びオートレベリング機構並びにその制御部を示す構成図である。

【図6】フォーカス位置の計測値の補正方法の説明図である。

【図7】（a）は応答周波数νが10Hzの場合の伝達関数を示す図、（b）は図7（a）の伝達関数を逆フーリエ変換して得られた位置関数を示す図である。

【図8】（a）は隣接するショット領域へ露光を行う場合のウエハの軌跡を示す図、（b）はレチクルの走査時のタイミングチャート、（c）はウエハの走査時のタイミングチャートである。

【図9】（a）は露光位置制御法でレベリング及びフォーカシングを行う場合の追従精度を示す図、（b）は先読み制御法でレベリング及びフォーカシングを行う場合の追従精度を示す図である。

【図10】（a）は露光位置制御法を使用した場合の曲がりパラメータFに対する誤差パラメータSの計算結果を示す図、（b）は先読み制御法を使用した場合の曲がりパラメータFに対する誤差パラメータSの計算結果を示す図である。

【図11】（a）及び（b）は先読み制御法における平均化効果の説明図、（c）及び（d）は露光位置制御を行う場合のフォーカス面を示す図、（e）及び（f）は先読み制御を行う場合のフォーカス面を示す図である。

【図12】（a）及び（b）は露光位置制御を行う場合のフォーカス位置のサンプル点を示す平面図、（c）及び（d）は完全先読み制御を行う場合のフォーカス位置のサンプル点を示す平面図、（e）及び（f）は分割先読み制御を行う場合のフォーカス位置のサンプル点を示す平面図である。

【図13】（a）～（d）は完全先読み制御法で露光を行う場合の制御法の説明図、（e）～（h）は分割先読み制御法で露光を行う場合の制御法の説明図である。

【図１４】（ａ）は一括露光を行う場合のフォーカス誤差を示す図、（ｂ）はスリットスキャン露光方式で露光を行う場合のフォーカス誤差を示す図である。

【図１５】（ａ）は計測値の最大値と最小値とを用いてオートフォーカス制御を行う場合のフォーカス誤差を示す図、（ｂ）は計測値の平均値を用いてオートフォーカスを行う場合のフォーカス誤差を示す図、（ｃ）は時間遅れ誤差を示す図、（ｄ）はサーボゲインの変化を示す図である。

【図１６】スリット状の露光フィールドでウエハ上のショット領域への露光を行う状態を示す平面図である。

【図１７】（ａ）はスキャン方向の応答周波数と非スキャン方向の応答周波数とを等しくしてレベリング制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図、（ｂ）はスキャン方向の応答周波数を非スキャン方向の応答周波数より高くしてレベリング制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図である。

【図１８】（ａ）はフォーカス位置の平均値を用いてオートフォーカス制御を行う状態を示す図、（ｂ）はフォーカス位置の最大値及び最小値の平均値を用いてオートフォーカス制御を行う状態を示す図である。

【図１９】（ａ）は図１７（ａ）の状態において更に平均化処理でオートフォーカス制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図、（ｂ）は図１７（ｂ）の状態において更にフォーカス位置の最大値及び最小値の平均値を用いてオートフォーカス制御を行った場合の曲がりパラメータＦに対する誤差パラメータＳの計算結果を示す図である。

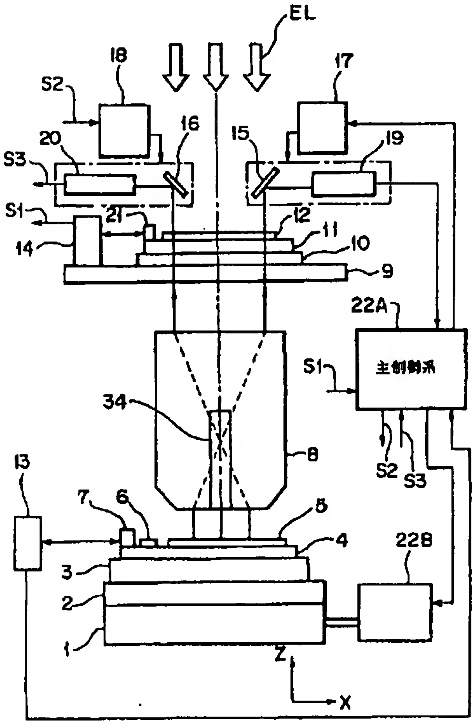
【図２０】従来のステッパーにおける多点フォーカス位置検出系を示す構成図である。

【図２１】（ａ）は図２０において投影光学系による露光フィールドを含む領域に投影された２次元的なスリット状の開口パターン像を示す平面図、（ｂ）は図２０の多点フォーカス位置検出系のパターン形成板上の開口パターンを示す図、（ｃ）は図２０の受光器上の受光素子の配列を示す図である。

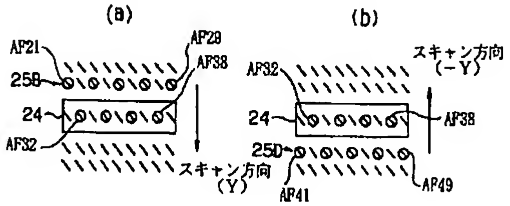
【符号の説明】

２	ウエハＹ軸駆動ステージ
４	Ｚレベリングステージ
５	ウエハ
８	投影光学系
１０	レチクルＹ駆動ステージ
１２	レチクル
２２Ａ	主制御系
２４	スリット状の露光フィールド
６２Ａ	パターン形成板
６９Ａ	受光器
７１Ａ	信号処理装置
ＡＦ１１〜ＡＦ５９	計測点

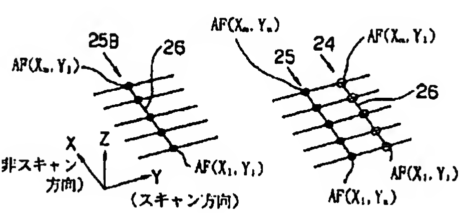
【図１】


EL
18
17
S2
16
15
20
19
S3
S1
21
12
11
10
14
9
22A
S1
主制御系
34
8
S2
S3
13
7
6
5
4
22B
3
2
1
Z
X

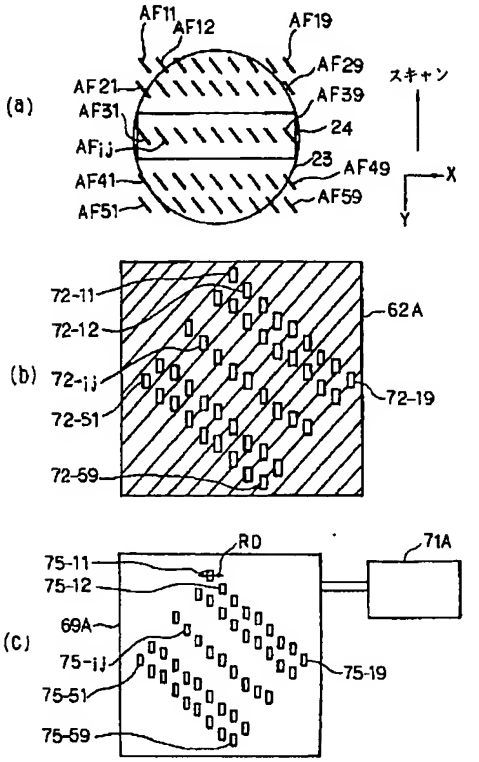
【図３】


(a)
(b)
AF21
AF29
AF38
25B
24
AF32
スキャン方向
（Y）
AF32
スキャン方向
（−Y）
24
AF38
25D
AF41
AF49

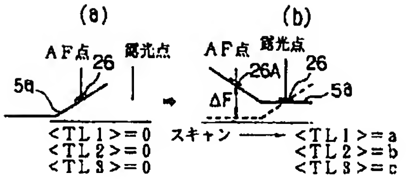
【図４】


(a)
(b)
25B
26
AF(Xm, Y1)
X
Z
(非スキャン方向)
Y
(スキャン方向)
AF(X1, Y1)
AF(Xm, Yn)
25
24
AF(Xm, Y1)
26
AF(X1, Y1)
AF(X1, Yn)

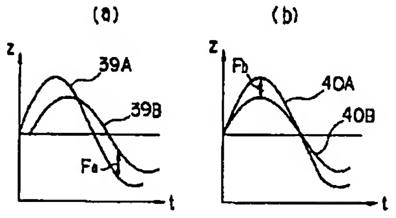
【図2】


(a)
AF11
AF12
AF19
AF29
AF21
AF31
AF39
AFij
24
23
AF49
AF41
AF51
AF59
スキャン
X
Y
(b)
72-11
72-12
72-ij
72-51
72-59
62A
72-19
(c)
RD
71A
75-11
75-12
69A
75-ij
75-51
75-59
75-19

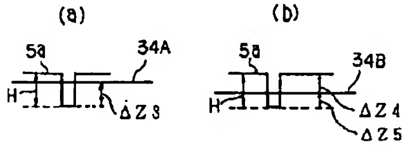
【図6】


(a)
AF点
26
露光点
5a
<TL1>=0
<TL2>=0
<TL3>=0
(b)
AF点
露光点
26A
26
5a
ΔF
スキャン
<TL1>=a
<TL2>=b
<TL3>=c

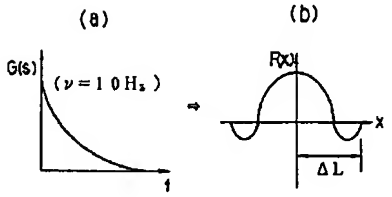
【図9】



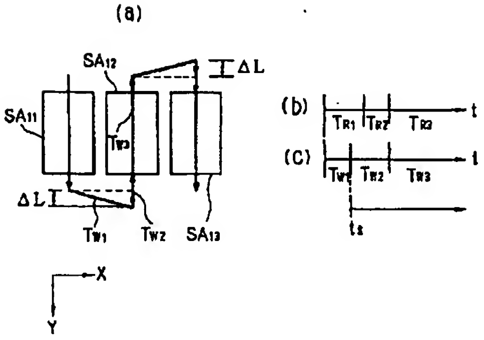
【図18】


(a)
5a
34A
H
ΔZ3
(b)
5a
34B
H
ΔZ4
ΔZ5

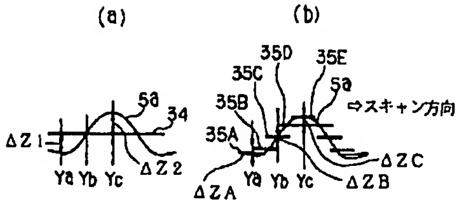
【図7】



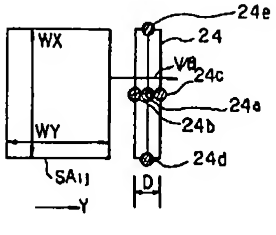
【図8】


(a)
SA12
ΔL
SA11
TW3
ΔL
TW1
TW2
SA13
X
Y
(b)
TR1
TR2
TR3
t
(C)
TW1
TW2
TW3
t
ts

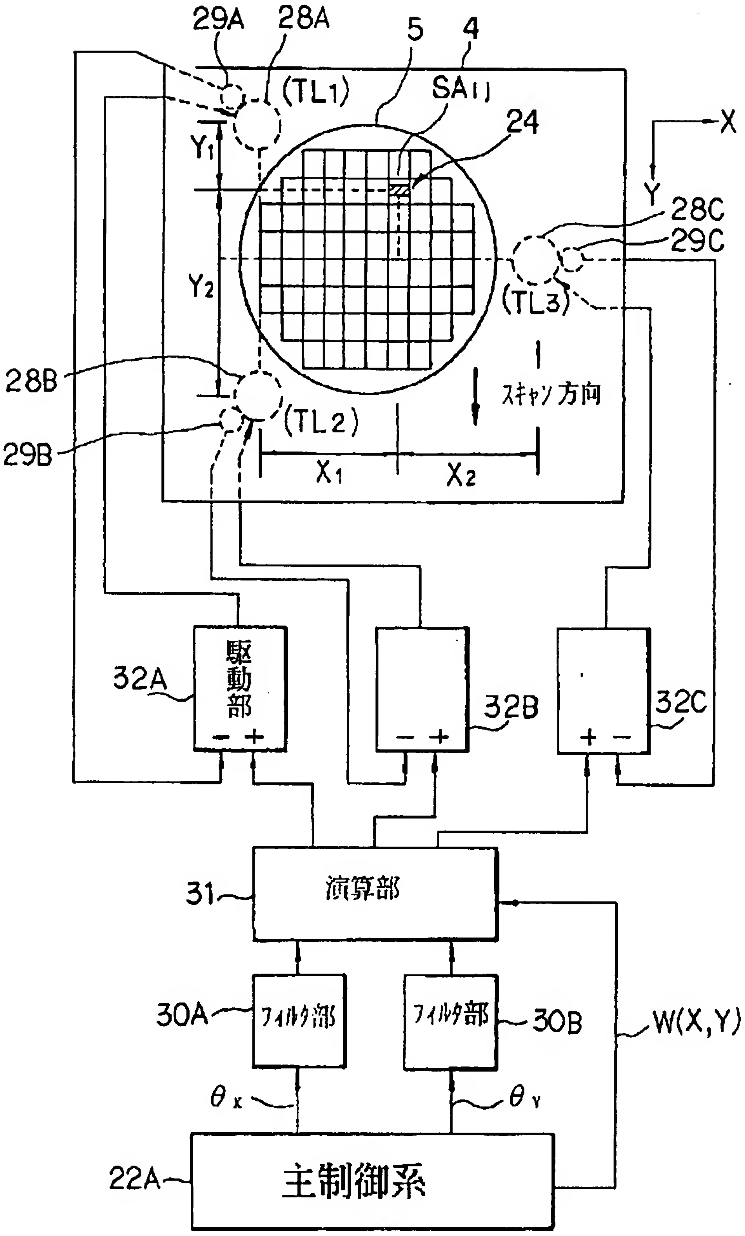
【図14】


(a)
5a
34
ΔZ1
ΔZ2
Ya
Yb
Yc
(b)
35D
35E
35C
5a
35B
⇨スキャン方向
35A
ΔZC
ΔZA
Ya
Yb
Yc
ΔZB

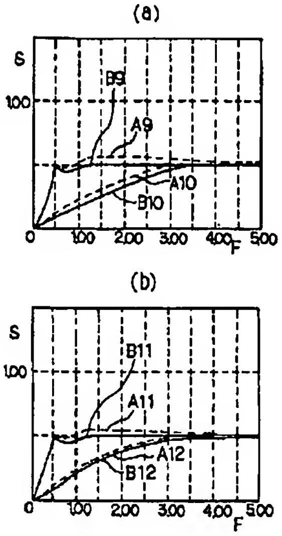
【図16】


24e
24
WX
VB
24c
24a
WY
24b
24d
SA11
Y
D

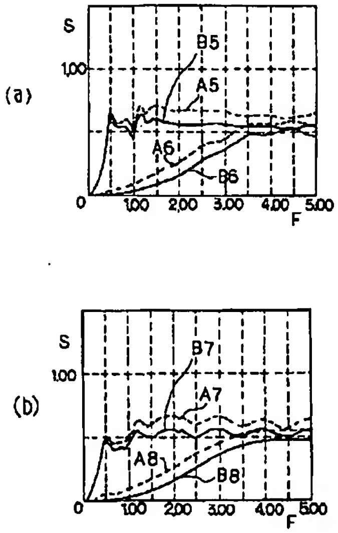
【図5】


29A
28A
5
4
(TL1)
SAij
24
X
Y
Y1
Y2
28C
29C
(TL3)
28B
(TL2)
29B
スキャン方向
X1
X2
32A
駆動部
－ ＋
32B
－ ＋
32C
＋ －
31
演算部
30A
フィルタ部
30B
フィルタ部
W(X,Y)
θx
θy
22A
主制御系

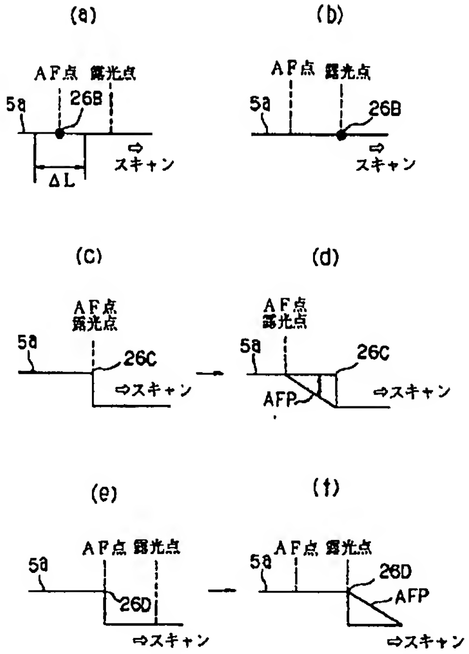
【図10】


(a)
S
1.00
B9
A9
A10
B10
0
1.00
2.00
3.00
4.00
5.00
F
(b)
S
1.00
B11
A11
A12
B12
0
1.00
2.00
3.00
4.00
5.00
F

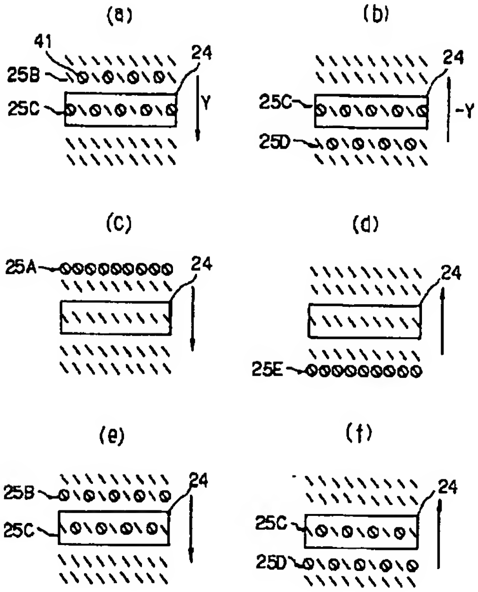
【図19】


(a)
S
1.00
B5
A5
A6
B6
0
1.00
2.00
3.00
4.00
5.00
F
(b)
S
1.00
B7
A7
A8
B8
0
1.00
2.00
3.00
4.00
5.00
F

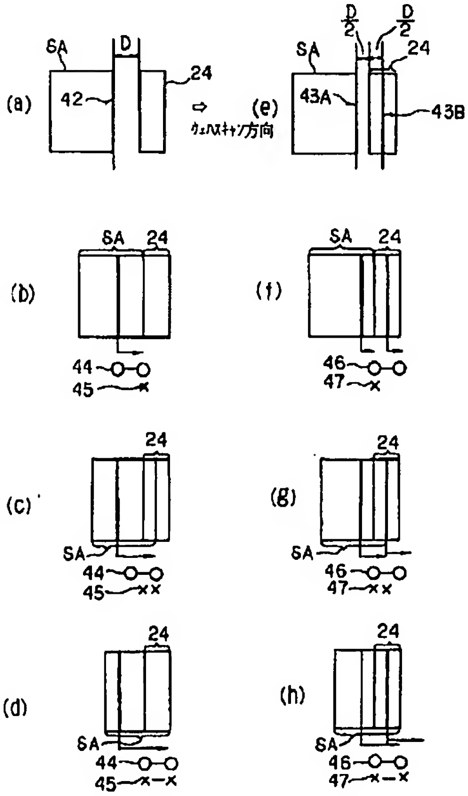
【図11】


(a)
AF点 露光点
5a
26B
ΔL
⇨ スキャン
(b)
AF点 露光点
5a
26B
⇨ スキャン
(c)
AF点 露光点
5a
26C
⇨スキャン
(d)
AF点 露光点
5a
26C
AFP
⇨スキャン
(e)
AF点 露光点
5a
26D
⇨スキャン
(f)
AF点 露光点
5a
26D
AFP
⇨スキャン

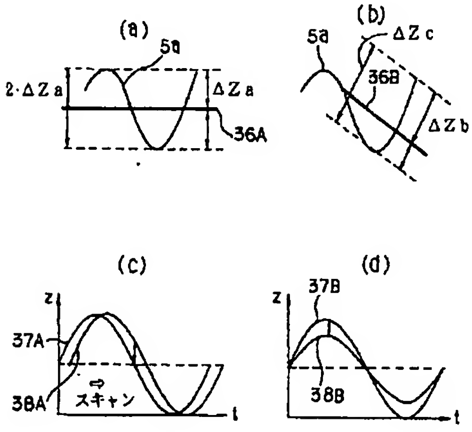
【図12】


(a)
41
24
25B
25C
Y
(b)
24
25C
-Y
25D
(c)
25A
24
(d)
24
25E
(e)
25B
24
25C
(f)
24
25C
25D

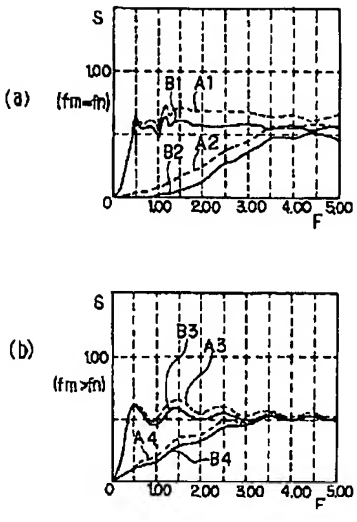
【図13】


(a)
SA
D
42
24
⇨ ウェハスキャン方向
(e)
D/2
D/2
SA
24
43A
43B
(b)
SA
24
44
45
(f)
SA
24
46
47
(c)
24
SA
44
45
(g)
24
SA
46
47
(d)
24
SA
44
45
(h)
24
SA
46
47

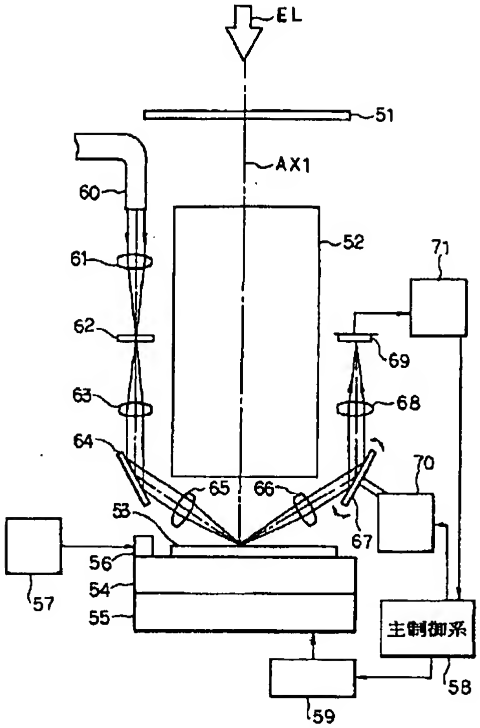
【図15】


(a)
5a
2·ΔZa
ΔZa
36A
(b)
5a
ΔZc
36B
ΔZb
(c)
z
37A
38A
⇨ スキャン
t
(d)
z
37B
38B
t

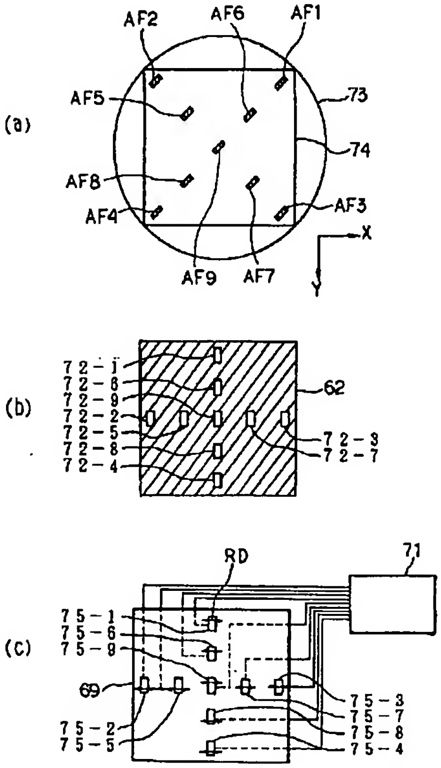
【図17】


S
1.00
(a)
(fm=fn)
B1
A1
B2
A2
0
1.00
2.00
3.00
4.00
5.00
F
S
(b)
B3
A3
1.00
(fm>fn)
A4
B4
0
1.00
2.00
3.00
4.00
5.00
F

【図20】


EL
51
AX1
60
52
61
71
62
69
63
68
64
65
66
70
53
67
56
54
57
55
主制御系
58
59

【図21】


(a)
AF1
AF2
AF3
AF4
AF5
AF6
AF7
AF8
AF9
73
74
X
Y
(b)
72－1
72－6
72－9
72－2
72－5
72－8
72－4
72－3
72－7
62
(c)
RD
71
75－1
75－6
75－9
69
75－2
75－5
75－3
75－7
75－8
75－4